**SOIL**
the upper layer of earth in which plants grow a black or dark brown material typically consisting of a mixture of organic remains, clay, and rock particles.

**Soil Formation**

Soil is the thin layer of loose material covering the earth’s surface. It is composed of both organic and inorganic materials. The formation of soil is an extremely long process taking up to an average of a thousand years. Soil is formed when surface rocks break into several smaller particles, called regolith, which then gets mixed with varied organic matter. This whole process is called **Weathering.**So weathering happens through three major ways, namely

* **Physical Weathering:**This is the geological process when rocks get fragmented into smaller particles, without changing the chemical composition of the rocks. This primarily happens due to fluctuating temperatures causing the rocks to break apart.
* **Chemical Weathering:** This is the erosion of rocks and other surface materials caused due to chemical reactions. The rocks react with substances in the atmosphere, such as moisture, air, water etc. The resulting substance has a different chemical composition than the rock from which it formed. Hydration, Hydrolysis, [Oxidation](https://www.toppr.com/guides/chemistry/aldehydes-ketones-and-carboxylic-acids/oxidation/), Carbonation and Reduction are the chemical processes involved in chemical weathering.
* **Biological Weathering:**This is the process of disintegration of rocks due to actions of living organisms (animals, plants, microbes etc.), like when a plant grows in the fissure of a rock and its roots exert pressure on the rock forcing in to break apart. Even microbes produce organic material that causes weathering.

**SOIL COMPOSITION**

Soil is essential a mix of various particles and substances. So let us have a look at all the things that make up soil,

* Minerals: A very important substance found in soil. Minerals basically formed by the breakdown of large rocks. Some of the most common minerals found in soil are, Iron, Potassium, Magnesium, Calcium, Sulphur etc.
* Humus: Humus is the organic substances that are formed due to decomposition of dead and decomposing plants and animals. It lends the soil its fertility.
* Living Organisms: These are mostly microbes and other organisms (such as worms, bacteria, fungi etc.) that live in the soil and perform the decomposition of animals and plants that gives the soil humus.
* Water and Air: Water and air form a part of the soil and allow living organisms to perform their functions. They also help in the process of photosynthesis.

##

**SOIL MINERALS**

Soil is basically a mixture of organic matter, liquids, minerals, gases, organisms, and microorganisms. All of the components of this mixture work together to support plant life and allow plants to thrive. Soil minerals perform a number of functions, including helping plants absorb water, adjusting soil pH, and providing nutrients to plants. Of all of the minerals found in soil, nitrogen, phosphorous, and potassium are the three most important that plants actively extract from the soil as nutrients. Correcting soil mineral content is an important part of raising healthy plants.

**EXPLAINATION**

Soil minerals can do a lot to improve the soil for different plants, especially in an indoor garden. For example, if the local soil is too basic for plants to properly absorb water and nutrients, lime can be added to make it more acidic. If the soil is too acidic, it can be made more basic with sulfur.

A good balance of nitrogen, phosphorous, and potassium is required to help plants grow and thrive. For example, while nitrogen is essential for the growth of leaves and stems, too much of it can delay flowering and/or stunt a plant’s growth. If a plant is showing retarded growth and/or purplish stems and leaves, it is likely that the soil is too low in phosphorous. If the leaves are spotted and mottled, and fruit yields are lower than expected, the soil may have a potassium deficiency.

Simply adding more of the deficient nutrient is not always the best solution to improve soil minerals, though. For example, a common rock mineral fertilizer is available to correct nitrogen deficient soil, but if the soil is already acidic, adding this mineral alone is not a good idea, as this fertilizer will increase the soil’s ph. To correct this, a significant amount of lime is also necessary.

**NUTRIENTS IN SOIL:**

**Plant nutrients** are the chemical elements that are essential to the nourishment of **plant** health. **Plant nutrients** fall into three categories, all of which are based on the amount a **plant** needs,

* PRIMARY NUTRIENTS
* SECONDARY NUTRIENTS
* TRACE NUTRIENTS
 Each **plant nutrient** performs a crucial role in **plant** growth and development.

**PRIMARY NUTRIENTS**

**The three primary nutrients in soil are NITROGEN, PHOSPHORUS and POTASSIUM. Together they make a Trio known as NPK**

**NITROGEN:**

Nitrogen is one of the important elements a plant needs. It is an important part of proteins, [chlorophyll](http://www.canna-uk.com/glossary#chlorophyll), vitamins, [hormones](http://www.canna-uk.com/plant_hormones) and DNA. Because it is a component of enzymes, nitrogen is involved in all enzyme reactions and plays an active role in the plant’s metabolism.

**Nitrogen** is mainly absorbed by the plant in the form of nitrate and ammonium. It can also be absorbed via small organic molecules. It is important that the balance between nitrate and ammonium is correct in the feeding otherwise the [pH](http://www.canna-uk.com/glossary#ph) in the rhizosphere (environment immediately surrounding the roots) will become too high or too low. Plants with nitrate as their source of nitrogen have a higher organic acid content. This has an influence on the taste and storage life of the harvest among other things.

Nitrate is converted into ammonium in the plant by the *nitroreductase enzyme*. Ammonium is then assimilated into organic molecules. Nitrogen has a positive influence on the **plant’s growth**. The plant gets bigger leaves, more branches and the vegetative period is extended.

**Deficiency**

* Quickly followed by larger leaves in the middle and top parts of the plant.
* The plant is a lighter color as a whole.
* Larger leaves in the lower part of the plant turn light green. The leaf stalks of the smaller leaves now also turn purple. Typical vertical purple stripes appear in the stem.
* Leaves in the lower part of the plant turn more yellow and then become white. Finally, the leaves whither and fall off.
* The growth is visibly inhibited giving shorter plants, thinner stems, less leaf formation and smaller leaves.
* Further yellowing and whitening occurs in the top and middle parts of the plant.
* Leaves on growing points remain green longer but they are a lot less green than at normal nitrogen levels.
* Forced flowering starts and there is substantial leaf loss.
* Substantial reduction in yield.

POTASSIUM

Potassium is an essential [**plant nutrient**](https://www.smart-fertilizer.com/articles/plant-nutrients) and is required in large amounts for proper growth and reproduction of plants. Potassium is considered second only to nitrogen, when it comes to nutrients needed by plants, and is commonly considered as the “quality nutrient.”

It affects the plant shape, size, color, taste and other measurements attributed to healthy produce.

Plants absorb potassium in its ionic form, K+.

**ROLES OF POTASSIUM IN PLANTS**

Potassium has many different roles in plants:

* In Photosynthesis, potassium regulates the opening and closing of stomata, and therefore regulates CO2 uptake.
* Potassium triggers activation of enzymes and is essential for production of Adenosine Triphosphate (ATP). ATP is an important energy source for many chemical processes taking place in plant issues.
* Potassium plays a major role in the regulation of water in plants (osmoregulation). Both uptake of water through plant roots and its loss through the stomata are affected by potassium.
* Known to improve drought resistance.
* Protein and starch synthesis in plants require potassium as well. Potassium is essential at almost every step of the protein synthesis. In starch synthesis, the enzyme responsible for the process is activated by potassium.
* Activation of enzymes – potassium has an important role in the activation of many growth related enzymes in plants.

## DEFICIENCY

Typical symptoms of potassium deficiency in plants include brown scorching and curling of leaf tips as well as [chlorosis](https://en.wikipedia.org/wiki/Chlorosis) (yellowing) between [leaf veins](https://en.wikipedia.org/wiki/Leaf#Veins). Purple spots may also appear on the leaf undersides. Plant growth, root development, and seed and fruit development are usually reduced in potassium-deficient plants. Often, potassium deficiency symptoms first appear on older (lower) leaves because potassium is a mobile nutrient, meaning that a plant can allocate potassium to younger leaves when it is K deficient. Deficient plants may be more prone to [frost](https://en.wikipedia.org/wiki/Frost) damage and disease, and their symptoms can often be confused with wind scorch or drought. The deficiency is most common in several important fruit and vegetable crops; notably [potatoes](https://en.wikipedia.org/wiki/Potato), [brassicas](https://en.wikipedia.org/wiki/Brassica), [tomatoes](https://en.wikipedia.org/wiki/Tomato), [apples](https://en.wikipedia.org/wiki/Apple), [currants](https://en.wikipedia.org/wiki/Ribes), [gooseberries](https://en.wikipedia.org/wiki/Gooseberry), and [raspberries](https://en.wikipedia.org/wiki/Raspberry). [Sugar beets](https://en.wikipedia.org/wiki/Sugar_beet), [cereals](https://en.wikipedia.org/wiki/Cereals), and [clover](https://en.wikipedia.org/wiki/Clover) are also commonly affected. Specific symptoms for each of these plants are as follows:

In potatoes, tuber size is much reduced and [crop yield](https://en.wikipedia.org/wiki/Crop_yield) is low. The leaves of the plant appear dull and are often blue-green in color with interveinal chlorosis. Leaves will also develop small, dark brown spots on the undersides and a bronzed appearance on the upper surfaces.

In brassicas, leaves are blue-green in color and may have a low degree of interveinal chlorosis. Scorching along the outside edges of leaves is common, and leaves are often tough in texture due to slow growth.

In tomatoes, the stems are woody and growth is slow. Leaves are blue-green in color, and the interveinal area often fades to a pale gray color. Leaves may also have a bronzed appearance and yellow and orange patches may develop on some of the leaflets. Fruits often ripen unevenly and sometimes have green patches near the stalks.

In apples, leaves are scorched around the edges, and interveinal chlorosis is common. Apple fruits often have a slightly acidic or woody taste.

In gooseberries, currants, and raspberries, [dieback](https://en.wikipedia.org/wiki/Forest_dieback) of shoots and branches is common and although the plant may produce many blossom buds in the early stages of deficiency, fruit yields turn out low and the fruits are of poor quality.

**ROLE OF PHOSPHORUS**

Phosphorus is responsible for a number of functions in plants which underlines its importance to the plants in your garden. The growth of plants is boosted by phosphorous whose lack leads to weak plants that fail to produce as expected. Plants require capturing the rays of the sun during photosynthesis. The following are the main functions performed by phosphorus in the life of plants:

* Stimulates root development necessary for the plant to get nutrients from the soil. The roots are also necessary for the support of the plant. When the roots are well developed, they are able to penetrate the ground and gather all the nutrients required by the plant for development.
* Boosts the development of the plant. Plants require nutrition for their development. The nutrition is processed in the leaves and then stored or transferred to other parts of the plants. Phosphorus is required for photosynthesis and also in the storage and transportation of the nutrients throughout the plant.
* Plants are expected to produce fruit after a given time if all the circumstances are right. Phosphorous is responsible for crop maturity at the right time. Plants that lack phosphorous take time to mature and when they do, the fruits or seeds they bear are few and poor in quality.
* Legumes help in fixing nitrogen in the soil through their roots. This function cannot be carried out well without phosphorous which boost the development of the roots.
* The substances required for the formation and development of genes cannot perform well without the availability of phosphorous. The transfer of the genes from one generation to the next is only possible when phosphorous is available.
* Plants that have access to enough phosphorous have the ability to resist diseases because all their parts are well developed and grow quickly. Plants grown using hydroponics are supplied with enough phosphorous to ensure they grow well.

## DEFICIENCY

In plants, [phosphorus](https://en.wikipedia.org/wiki/Phosphorus) (P) is considered second to nitrogen as the most essential nutrient to ensure health and function. Phosphorus is used by plants in numerous processes such as [photophosphorylation](https://en.wikipedia.org/wiki/Photophosphorylation), genetic transfer, the transportation of nutrients, and phospholipid cell membranes. Within a plant cell these functions are imperative for function; in photophosphorylation for example the creation of stored energy in plants is a result of a chemical reaction including phosphorus. Phosphorus is a key molecular component of genetic reproduction. When phosphorus is present in inadequate levels, genetic processes such as cell division and plant growth are impaired. Hence, phosphorus deficient plants may mature at a slower rate than plants with adequate amounts of phosphorus. The stunted growth induced by phosphorus deficiency has been correlated with smaller leaf sizes and a lessened number of leaves.[[3]](https://en.wikipedia.org/wiki/Phosphorus_deficiency#cite_note-3) Phosphorus deficiency may also create an imbalance in the storage of carbohydrates. Photosynthesis, the main function of plant cells that produces energy from sunlight and water, usually remains at a normal rate under a phosphorus-deficient state. However phosphorus usages in functions within the cell usually slow. This imbalance of rates in phosphorus deficient plants leads to the buildup of excess carbohydrate within the plant. This carbohydrate buildup often can be observed by the darkening of leaves. In some plants the leaf pigment change as a result of this process can turn leaves a dark purplish color.

**SECONDARY NUTRIENTS**

Calcium, magnesium, and sulfur are essential plant nutrients. They are called “secondary” nutrients because plants require them in smaller quantities than nitrogen, phosphorus, and potassium. On the other hand, plants require these nutrients in larger quantities than the “micronutrients” such as boron and molybdenum.

Calcium, magnesium, and sulfur are generally adequate in most Mississippi soils with favorable pH and organic matter levels. They affect pH when applied to the soil. Calcium and magnesium both increase soil pH, but sulfur from some sources reduces soil pH. Compounds containing one or more of these nutrients are often used as soil amendments rather than strictly as suppliers of plant nutrition.

### Calcium

The primary function of calcium in plant growth is to provide structural support to cell walls. Calcium also serves as a secondary messenger when plants are physically or biochemically stressed.

Calcium deficiencies rarely occur in Mississippi soils. Soils with favorable pH levels are normally not deficient in calcium. Acid soils with calcium contents of 500 pounds per acre or less are deficient for legumes, especially peanuts, alfalfa, clovers, and soybeans. At this level, limited root system crops such as tomatoes, peppers, and cucurbite would also need additional calcium. Soluble calcium is available as the Ca2+ ion and is needed for peanuts at pegging time and for peppers and tomatoes to prevent blossom end rot.

Available calcium can be lost from the soil when it is (a) dissolved and removed in drainage water, (b) removed by plants, (c) absorbed by soil organisms, (d) leached from the soil in rain water, or (e) absorbed by clay particles. Deficiency symptoms include death at the growing point, abnormally dark green foliage, weakened stems, shedding flowers, and any combination of these.

Limestone is the primary source of calcium in Mississippi. Other common sources include basic slag, gypsum, hydrated lime, and burned lime. These sources are recommended for peanuts, peppers, and tomatoes. In peanuts, they prevent pops and encourage pegging. In tomatoes and peppers, they prevent pops and blossom end rot. Hydrated lime and burned lime contain more readily available calcium than do basic slag and gypsum. Gypsum does not affect soil pH even though it contains calcium.

### Magnesium

Magnesium is adequate for crop production in most Mississippi soils except the coarse sandy soils of the Coastal Plains and the heavy dark clays of the Black belt Prairie. Magnesium is absorbed as the Mg2+ ion and is mobile in plants, moving from the older to the younger leaves. It leaches from the soil like calcium and potassium.

Magnesium is the central atom amid four nitrogen atoms in the chlorophyll molecule, so it is involved in photosynthesis. It serves as an activator for many enzymes required in plant growth processes and stabilizes the nucleic acids.

Interveinal chlorosis is a deficiency symptom in crops such as legumes, corn, sorghum, cotton, and certain leafy vegetables. (Interveinal chlorosis is a yellowing between the veins while the veins remain green.) The leaves may become pink to light red and may curl upward along the margins.

To correct magnesium deficiency in soil, use dolomitic lime when lime is needed; use soluble sources of magnesium when lime is not needed. Magnesium supplementation may be needed for cotton production in the Black land Prairie.

Cattle are often affected by grass tetany when forage magnesium content is low. Other factors include nitrogen, calcium, and potassium levels, stage of growth (usually in spring), whether or not cattle are lactating, and seasonal conditions. Dolomitic limestone is recommended as a liming material where grass tetany has been a problem. Give grazing animals’ supplemental magnesium and calcium when grass tetany is an issue.

The most common soluble sources of magnesium to use as fertilizer are magnesium sulfate (containing 10% Mg and 14% S, also known as Epsom salt), sulphate of potash magnesia (containing 11.2% Mg, 22% S, and 22% K2O, commercially sold as K-Mag), and magnesium oxide (containing 55% Mg, also known as magnesia).

### Sulfur

Sulfur is needed in fairly large quantities by most crops. It is an essential building block in chlorophyll development and protein synthesis. Sulfur is required by the rhizobia bacteria in legumes for nitrogen fixation. In general, crops remove about as much sulfur as they do phosphorus. Grasses remove sulfur more efficiently than legumes, and clovers often disappear from pasture mixtures when sulfur is low.

The sulfate ion, SO4, is the form primarily absorbed by plants. Sulfate is soluble and is easily lost from soils by leaching. As sulfate is leached down into soil, it accumulates in heavier (higher clay content) subsoil. For this reason, testing for sulfur in topsoil is unreliable for predicting sulfur availability during a long growing season.

Many coarse-textured, sandy soils and low organic matter, salty soils throughout Mississippi are sulfur deficient for crop production. Many acid soils contain metallic sulfides that release sulfur as weathering occurs.

Sulfur deficiency symptoms show on young leaves first. The leaves appear pale green to yellow. The plants are spindly and small with retarded growth and delayed fruiting. For a rapid correction of a deficiency, use one of the readily available sulfate sources.

Sulfur may be recommended for major crops in Mississippi at 8–10 pounds per acre annually in some situations. Check with local MSU Extension Service offices or area agronomists for more crop- and site-specific information.

There are many sources of fertilizer sulfur available. Organic matter is the source of organic sulfur compounds and is the main source of soil sulfur in most Mississippi soils. Other sources of sulfur are rainfall and fertilizers that contain sulfur. Some readily available sources include ammonium sulfate (21% N and 24% S), potassium sulfate (50% K20 and 17.6% S), gypsum (32.6% CaO and 16.8% S), and zinc sulfate (36.4% Zn and 17.8% S).There are several other sulfate sources as well as less available sources of sulfur in the elemental or sulfide form.

Elemental sulfur is a good acidifying agent. An application of 500 pounds of sulfur per acre on sandy loam soil reduces the pH from 7.5 to 6.5. It takes about 3 pounds of lime to neutralize the acidity formed by 1 pound of sulfur.

**TRACE NUTRIENTS**

|  |  |
| --- | --- |
| IRON(Fe) | Iron is a constituent of many compounds that regulate and promote growth and is readily available in the North Coast's acid soils. |
| MAGANESE (Mn) | Manganese helps with photosynthesis. It is freely available in the North Coast's acid soils, often in toxic amounts in very acid soils, but can be deficient in sandy soils. Toxicity is remedied with lime. |
| COPPER (Cu) | Copper is an essential constituent of enzymes in plants and is readily available in North Coast soils, although it can be deficient in red soils. Overuse of another trace element, molybdenum, can cause copper deficiency in animals. Toxicity can be a problem for horticulturists who regularly use Bordeaux mixture or copper oxychloride sprays to control diseases on horticultural crops. |
| ZINC(Zn) | Zinc helps in the production of a plant hormone responsible for stem elongation and leaf expansion. It is readily available in acid soils, but combines easily with iron in the North Coast's red soils. This is easily cured with the addition of zinc sulfate or crushed zinc minerals. Fruit trees can be sprayed with zinc. |
| BORON(B) | Boron helps with the formation of cell walls in rapidly growing tissue. Deficiency reduces the uptake of calcium and inhibits the plant's ability to use it. It is chronically deficient in North Coast soils used for horticulture but this is easily remedied with borax applied to the soil. |
| MOLYBDENUM (Mo) | Molybdenum helps bacteria and soil organisms convert nitrogen in the air to soluble nitrogen compounds in the soil, so is particularly needed by legumes. It is also essential in the formation of proteins from soluble nitrogen compounds.Molybdenum deficiency is prevalent in the North Coast's acid soils, but can be remedied easily with applications of Mo super, molybdenum trioxide (applied during inoculation and lime pelleting of legume seed), or sodium molybdate. |