SCI – SOIL AND PLANT GROWTH

For their best growth, plants need a root environment that supplies optimal amounts of mineral nutrients, water and air (oxygen). The pH (relative acidity) and salinity (salt concentration) of the soil are also critically important. Soil fertility, the soil's ability to support plant growth, often refers specifically to the presence of proper amounts of nutrients. But the soil's ability to meet all the other needs of plants is another component of soil fertility.

Mineral Nutrients and Nutrient-Holding Capacity

Mineral nutrients – phosphate (PO_4^{3-}), potassium (K^+), calcium (Ca^{2+}), and other ions – are present in various rocks, along with non-nutrient elements. Minerals initially become available to roots through the weathering of rock. Weathering, however, is much too slow to support normal plant growth. The nutrients that support plant growth in natural ecosystems are supplied mostly through the breakdown and release (recycling) of nutrients from detritus.

Nutrients may literally be washed from the soil as water moves through it, a process called leaching. Leaching not only lessens soil fertility, but also contributes to pollution when materials removed from the soil enter waterways. Consequently, the soil's capacity to bind and hold nutrient ions until they are absorbed by roots is just as important as the initial supply of those ions. This property is referred to as the soil's nutrient holding capacity or its ion-exchanging capacity.

In agricultural systems, there is an unavoidable removal of nutrients from the soil with each crop because nutrients absorbed by plants are contained in the harvested materials. Therefore, agricultural systems require inputs of nutrients to replace those removed with the harvest. Nutrients are replenished with applications of fertilizer – material that contains one or more of the necessary nutrients. Fertilizer may be organic or inorganic. Organic fertilizer includes plant or animal wastes or both; manure and compost (rotted organic material) are two examples. Organic fertilizer also includes leguminous fallow crops (alfalfa, clover) or food crops (lentils, pea), which fix atmospheric nitrogen. Inorganic fertilizers are chemical formulations of required nutrients, without any organic matter included. Inorganic fertilizers are much more prone to leaching than organic fertilizers.

Aeration

Novice gardeners commonly kill plants by overwatering, or "drowning" them. Roots need to "breathe." Basically, they are living organs and need a constant supply of oxygen for energy vial metabolism. Land plants depend on the soil being loose and porous enough to allow the diffusion of oxygen into, and carbon dioxide out of, the soil, a property called soil aeration. Overwatering fills the air spaces in the soil, preventing adequate aeration. So does compaction or packing of the soil, which occurs with excessive foot or vehicular traffic. Compaction also reduces infiltration and increases runoff.

Relative Acidity (pH)

The term pH refers to the acidity or alkalinity (basicity) of any solution. A solution that is neither acidic nor alkaline is said to be neutral and has a pH of 7. The pH scale, runs from 1 to 14. It is important to know that different plants are adapted to different pH ranges. Most plants (as well as animals) do best with a pH near neutral.

Salt and Water Uptake

A build-up of salts in the soil makes it impossible for the roots of a plant to take in water. Indeed, if salt levels in the soil get high enough, water can be drawn out of the plant (by osmosis), resulting in dehydration and death. Only plants with special adaptations can survive saline soils, and to date none of those are crop plants.

Water and Water-holding Capacity

Water is constantly being absorbed by the roots of plants, passing up through the plants and exiting as water vapour through microscopic pores in the leaves—a process called transpiration. The pores, called stomata (sing. stoma), are essential to permit the entry of carbon dioxide and exit of oxygen in photosynthesis; however, the plant's loss of water via transpiration through the stomata is dramatic. A field of corn, for example, transpires an equivalent of a field-sized layer of water 17inches (43cm) deep in a single growing season. Inadequate water results in wilting, a condition that conserves water but also shuts off photosynthesis by closing the stomata and preventing gas from being exchanged. If the wilted condition is too severe or too prolonged, the plants die.

Water is resupplied to the soil naturally by rainfall or artificially by irrigation. Three attributes of the soil are significant in this respect. First is the soil's ability to allow water to infiltrate, or soak in. if water runs off the ground surface, it won't be useful. Worse, it may cause erosion.

Second, is the soil's ability to hold water after it infiltrates, a property called water-holding capacity. Poor water holding capacity implies that most of the infiltrating water percolates on down below the reach of roots—not very far in the case of seedlings and small plants—again becoming useless. What is desired is a good water-holding capacity—the ability to hold a large amount of water like a sponge—providing a reservoir from which plants can draw between rains. If the soil does not have such water-holding capacity, the plants will have to depend on frequent rains or irrigation or suffer the consequences of drought. Sandy soils are notorious for the poor water-holding capacity, whereas clayey (or silty) soils are good at holding water.

The third critical attribute of the soil is evaporative water loss from the soil surface. This kind of evaporation depletes the soil's water reservoir without serving the needs of plants. The O horizon function well to reduce evaporative water loss by covering the soil.