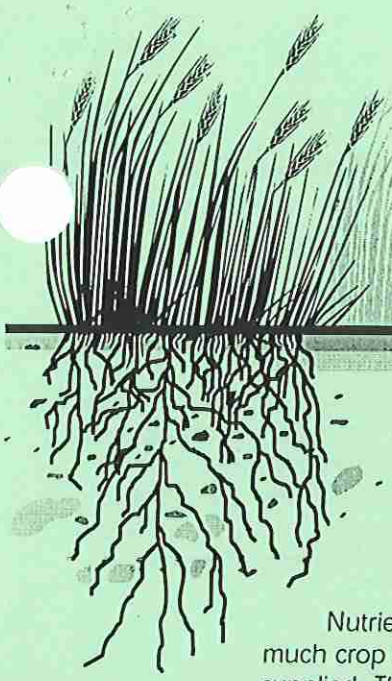

Soil Quality ▪ Agronomy

Technical Note No. 4

Effect of Soil Quality on Nutrient Efficiency

USDA

United States Department of Agriculture

Natural Resources Conservation Service

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This is the fourth Agronomy fact sheet in a series on on soil quality. This fact sheet is general. For specific application, contact your NRCS State Agronomist.

Nutrient efficiency is a measure of how much crop is produced per unit of nutrient supplied. The higher the efficiency, the more product is produced per unit of nutrient. The quality of soil affects nutrient use efficiency. Soil quality is measured or evaluated by a number of indicators. This technical note will discuss how 13 indicators relates to nutrient efficiency.

1. Soil Quality definition with regards to nutrients

A healthy soil functioning at nearly full capacity stores and cycles nutrients and allows crops to grow and use nutrients efficiently. In a healthy soil, nutrients become available when the plants need them. There is little risk for crop nutrients to move below the root zone through leaching, off the edge of field by runoff and erosion, or above the crop canopy by volatilization. Crop nutrients that move beyond the crop's zone of uptake could potentially contaminate the environment.

2. Erosion

Erosion and runoff are both detrimental to nutrient management. Nutrients contained in the topsoil, along with soil organic matter, can be carried away by erosion or washed out with runoff water. The organic matter is the first to be transported by water or wind because of its lower specific gravity. Additional nutrients are required to maintain productivity lost when topsoil is carried away by erosion.

3. Deposition of Sediment

Sediment additions in the field can be good or bad. Some sediment, especially the finer clay particles and organic matter, bring in nutrients. The coarser sediments, like sands, do not have a high nutrient content and tend to cover the topsoil that is in place. Coarser textured soils also lack moisture-holding and pesticide-retention capacity.

4. Compaction

Compact soils restrict the movement of roots. Less root volume in the soil prevents nutrient uptake. Compaction also restricts the diffusion and flow of nutrients in the soil. Few roots and limited nutrient movement can result in stunted growth because the plant is unable to take up the nutrients in the soil. Compacted soils retard air movement and gas exchange in the root zone. This can lead to nutrient losses, like denitrification or toxic gas build-up near the roots.

5. Soil Aggregation at the Soil Surface

Good soil aggregation means better water and nutrient movement through the soil. More aggregation means more of the surface area of the soil particles have capacity for adsorbed nutrients. Surface aggregation allows pore space for water infiltration and gas exchanges. Good soil aggregation is closely tied to the amount of active organic matter and to biological activity. Thus soil aggregation is connected to nutrient cycling.

6. Infiltration

Plants require water. Nutrients move with the water through the soil pores and are absorbed into the plant. When nutrients are applied to the soil surface, as in no-till systems, water is required to move the nutrients down into the root zone. Good soil infiltration permits this to happen. Nutrients that are not carried

into the root zone are susceptible to runoff. Percolating water carries the nutrients deeper into the root zone and also removes harmful salts that may accumulate there.

7. Soil Crusting

Crusting seals the soil surface and restricts water infiltration and gas exchange. If not allowed to infiltrate, surface applied nutrients on crusted soils are susceptible to runoff and wind transport. Crusting also reduces seed germination and seedling survival which directly has an effect on the plant population and the amount of nutrients necessary for the crop.

8. Nutrient Loss or Imbalance

Nutrients need to be applied according to the crop and soil requirements. Soil and plant analyses are a good way to determine the amount of nutrients needed. Over-application of nutrients can lead to plant toxicity, poor pH reaction, and excess nutrients susceptible to runoff, leaching, and volatilization. A deficiency in nutrients will not sustain optimum plant growth.

9. Pesticide Carryover

Pesticides with residual soil activity can stunt growth of subsequent crops. If roots are affected, their ability to absorb nutrients will be lessened. Any effect on plant photosynthesis will reduce nutrient uptake and metabolism. Without pesticide or weed control, weeds can utilize nutrients in competition of the crop. The weed residue may not decompose and recycle plant nutrients for the subsequent crops.

10. Organic Matter

Soil organic matter is a very valuable component of the topsoil. Organic matter stores nutrients, feeds soil organisms that decompose organic material, and return the basic nutrients to the soil. Organic matter holds soil moisture for plant use. Soil organic matter is developed by combining of carbon, oxygen, and nitrogen plus other nutrients in the soil. Nitrogen and other nutrients must be available to soil microorganisms for development of organic matter.

11. Biological Activity

A healthy soil has a diverse set of macro and micro organisms that assure a well functioning soil food web. Microorganisms decompose organic material, store nutrients in their bodies, and as they decay or become food for other organisms, they release nutrients. Some small animals like insects and crustacea carry organic material and related nutrients into the soil and aid in its decomposition. Some microorganisms have a symbiotic relationship with plants such as mycorrhiza. Mycorrhiza live in plant roots and help the plants assimilate water and nutrients.

12. Weeds and Pathogens

Nutrients can be used by crops or by weeds. Weeds utilize nutrients, but fail to produce a marketable commodity. So, the nutrients are not efficiently used to grow crops. The same is true for crops that are attacked by disease and insects. Efficient utilization means nutrients are converted to a harvestable product.

13. Extreme Soil Moisture Conditions

The amount of soil moisture impacts nutrient cycling. A dry soil does not promote root extension in the root zone. And, since nutrients are carried by water, plants are unable to obtain adequate nutrition. Waterlogged soils affect the transformation of nutrients. Phosphorus becomes more mobile and less attached to minerals in waterlogged conditions. Nitrate nitrogen is denitrified by changing form from a liquid to a gas which can be lost to the atmosphere. Roots consume oxygen and respire carbon dioxide. Because gases are transported much more slowly through water (about one ten thousanth slower) than air, some gases such as carbon dioxide can accumulate in the soil and be toxic to roots.

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