Alkaline Soils

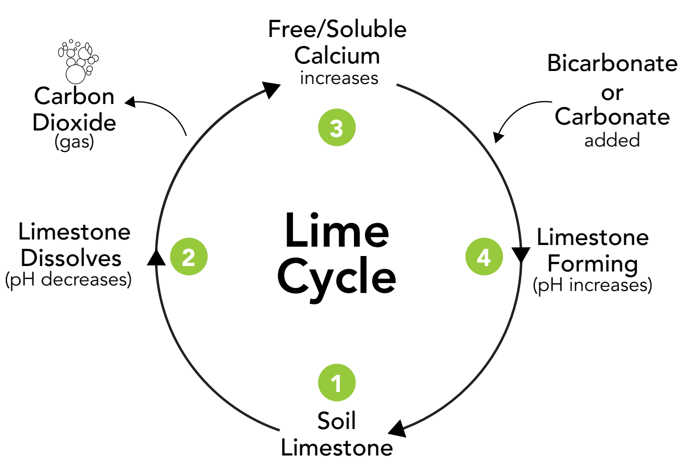
AGRONOMY

Soils with a pH greater than 7.0 are considered alkaline. Alkaline soils often occur in arid regions that receive less than 25 inches of rain per year. Geographically, a combination of acid and alkaline soils exists between the Mississippi and Missouri Rivers, and the majority of the soils west of the Missouri River are alkaline. Soil alkalinity is caused by limestone that naturally exists in these arid soils. The effect of limestone and the interaction of irrigation water minerals on soil pH and soil productivity are discussed below.

Lime Cycle

Understanding the lime cycle, see Figure 1, is an essential beginning for understanding soil pH in alkaline soils.

Figure 1. Lime Cycle



❶ Beginning at the bottom of the cycle, soils can contain up to 60 percent limestone. In other words, an acre furrow slice of soil (2 million pounds) can contain up to 1.2 million pounds of limestone. However, most arid soils contain around 2 to 10 percent limestone (40,000 to 200,000 pounds).

❷ Chemically, limestone is calcium carbonate ($CaCO_3$), and as this compound dissolves, the soil pH decreases or becomes more acidic. A product of this reaction is free calcium and carbon dioxide, which is given off as a gas. This can be demonstrated by adding vinegar (acid) to many alkaline soils. You will note a violent effervescence of carbon-dioxide gas as the limestone is dissolved by the acid.

❸ As free or soluble levels of soil calcium increase, soil pH will be lowered (7.3 to 7.8). The soil pH will not drop below 7.3 until all of the limestone in the soil has been dissolved.

❹ When bicarbonate or carbonate is added to the soil (i.e., irrigation water), limestone is formed. In this process, free calcium levels in the soil are decreased and the pH increases.

Managing alkaline soil pH is best done by maintaining high levels of free calcium in the soil. This is why gypsum is added to soils with high soil pH (>8.0). Gypsum is an excellent and inexpensive source of soluble calcium. The soluble calcium removes the carbonate from the soil by forming limestone. This, in turn, lowers the soil pH. Elemental sulfur can also be used in the same way to lower soil pH. Elemental sulfur reacts with soil limestone which, in turn, creates gypsum.

Irrigation Water Quality

Arid soils often require irrigation for crop production. Poor quality irrigation water can result in a build-up of soil salts and high soil pH. The chief minerals in irrigation water are chloride, sulfate, bicarbonate, sodium, calcium, and magnesium. These minerals, contained in the irrigation water, can build up in the soil and cause problems. Sodium, bicarbonate, and chloride are the three minerals that contribute most to soil salinity and alkalinity.

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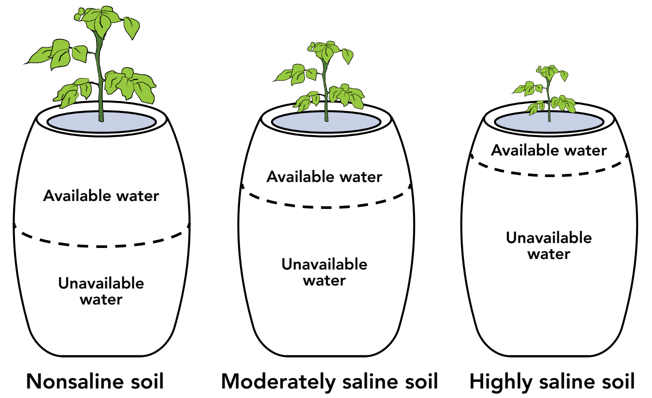
Water that contains measurable levels of bicarbonate and chloride will almost always contain high levels of sodium as well. Continued irrigation with sodium water will result in the soil "plugging up" because high sodium concentrations make the soil's clay and organic matter particles repel each other. This repulsion (dispersion) makes the clay break up and behave as an individual clay particle. Small, individual clay particles can then pack themselves in the small soil pores and plug them up.

Calcium has the opposite effect on soil clay. Calcium makes the clay particles flocculate, or come together, behaving as a larger soil particle. This encourages good drainage. Obviously, clay dispersion is not a problem for sandy textured soils with low clay content.

Bicarbonate, as previously discussed in the lime cycle, results in soil calcium forming limestone. After repeated use of waters with high carbonate, soil calcium (both exchangeable and soluble) will be low and bicarbonate levels in the soil will be high because there is no more calcium in the soil to bind with and form limestone. Soil pH levels can be greater than 8.5 when water with bicarbonate is used.

Chloride-containing irrigation waters nearly always have high sodium also. Chloride affects soil productivity by reducing the amount of water available to the crop. The effects of salt build-up in the soil on the amount of available water is depicted in Figure 2.

Figure 2. Effects of salt build-up on available water



More frequent irrigations become necessary to keep up with increasing soil salinity levels. Many agronomic crops are most sensitive to saline soils during germination. Once established, many crops can tolerate higher soil salinity. Leaching and/or drainage have to be established to flush the salt levels below the root zone.

Conclusion

Limestone is responsible for alkaline soil pH (7.0-8.5). Soil pH values above 8.5 are the result of irrigation waters containing bicarbonate. Irrigation waters containing high amounts of sodium result in poor drainage of medium and fine textured soils. Salt build-up is common with waters containing sodium chloride. A soluble source of calcium such as gypsum is the best way to reclaim these soils.

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