Producing forage on desert soils
By Jay Norton
(Wyoming Livestock Roundup, Volume 20, Number 33, January 10, 2009)

The high desert soils of Wyoming agricultural basins pose important management problems for producers of irrigated hay and pasture. In particular, producers must deal with high concentrations of soluble salts, high pH and very low organic matter contents. This article discusses these issues and how to cope with them for irrigated hay and pasture production.

Production Constraints

Over thousands of years in wet climates, soluble salts leach deep into or through the soil. But in dry climates like Wyoming, salts accumulate near the soil surface because a great deal more water can potentially evaporate from the surface than falls as precipitation. Rain soaks in, dissolves salts, and then warm, dry weather pulls it back to the surface. The water evaporates, but the salts accumulate. Though the salts can contain essential plant nutrients, excess calcium, magnesium, and sodium salts raise the pH and limit availability of other nutrients. Phosphorus (P) in particular binds rapidly with excess calcium to become “fixed” in a mineral form not available to plants.

Large amounts of sodium salts are especially detrimental to soils because excess sodium destroys drainage and aeration by breaking down porous soil aggregates. Leaching to remove salt or adding gypsum (calcium sulfate) and leaching to remove sodium are remedies for salt-affected soils that typically don’t work in Wyoming situations. Leaching requires deep drainage and abundant high-quality irrigation water. Gypsum works by chemically replacing sodium ions with calcium ions, but our soils are typically already very high in calcium.

pH is a measure of the acidity or alkalinity of soils where pH equal to 7.0 is neutral, pH less than 7.0 is acidic, and pH greater than 7.0 is alkaline. Strongly acid, low pH soils have problems with plant-availability of potentially toxic elements like heavy metals, while alkaline high pH soils have problems with low plant-availability of essential nutrients. The pH is related to the amount of calcium and magnesium carbonate in the soil, and high concentrations of carbonates hold pH stubbornly in the 8.0 to 8.5 range. Wyoming agricultural soils often have pH of about 8.0 to 8.5, which reduces availability of P, iron, zinc, and other nutrients because these elements combine with the abundant calcium to form insoluble mineral compounds.

Soil organic matter contributes to soil fertility both chemically, as it holds nutrients and releases them to plants, and physically, as it increases porosity of the soil, increasing water absorbing and holding capacity as well as flow of air. Low rainfall means low productivity with meager inputs of plant residues and, as a result, low soil organic matter content. Wyoming soils also go through many wetting-drying and freeze-thaw cycles that destroy cellular structures in plant residues, speeding decomposition and loss of the already small amount of organic matter (think of rewetting a dehydrated banana, or thawing a frozen one; the result would likely decompose more rapidly than a fresh banana).
Though it seems long-term irrigation and crop production would alter these properties for better or worse, the fact is that salt contents, especially calcium carbonates, are so high we can’t really run enough water through to really impact how they affect soil properties. Low-quality irrigation water high in soluble salts can destroy the productivity of soils. Though irrigation definitely increases productivity and the potential for more organic matter, harvest removes most organic material and the intense wetting and drying cycles that come with irrigation speed organic matter loss, as does nitrogen (N) fertilizer, which stimulates microbial decomposer populations. Tillage also speeds loss of organic matter by breaking soil aggregates and increasing air access to decomposing microbes; like stirring the compost pile.

**Soil management for more forage**

The key to optimal irrigated forage production in Wyoming is knowing and understanding the fertility status of soils. Occasional soil tests (at least once per year or two) give producers a rundown of nutrient, salt, and organic matter contents, as well as the pH, water-holding capacity, and other information crucial to good management. Soil sampling should be done at least six months prior to fertilizer application. The University of Wyoming has publications that describe how to collect samples and interpret results (see Internet links below).

**Fertilizing Alfalfa**

Alfalfa is well adapted to high pH soils that are deep and well drained and is the most popular forage crop in Wyoming with about 570,000 acres harvested in 2007. Optimal yields extract a great deal of nutrients from the soil: about 55 pounds of N per ton harvested per acre, 15 pounds of phosphate, and 60 pounds of potassium, as well as appreciable sulfur, zinc, and boron. Since alfalfa fixes all the N it needs from the atmosphere, there is no need to apply N. In fact, applying N fertilizer to alfalfa is a good way to weaken the stand and favor any grasses or weeds that are present. Ten to 15 pounds per acre of N at planting can speed establishment, but, with proper inoculation with N-fixing bacteria, new alfalfa stands begin fixing N rapidly.

In mixed grass-alfalfa stands, the alfalfa can supply all the N needs of the grass. Applying N fertilizer favors the grasses and will decrease the amount of alfalfa. Pure grass stands respond well to N fertilizer, but the form and application method should be considered.

Phosphorus is most often limiting for alfalfa yield and should be applied every year if indicated by a soil test. Although producers in many parts of the United States can get away with multi-year applications of P (i.e., applying two or three years worth at once), our high soil calcium contents can rapidly tie up excess P, so we recommend annual applications for Wyoming. Exceptions might be southeastern and northeastern Wyoming where higher precipitation creates lower soil pH and calcium contents.

Recent research shows the source of P does not impact yield, so, unless liquid formulations are much cheaper to apply in specific operations, the price per unit P should be the first consideration. Banding granular P fertilizer at planting time speeds establishment, but broadcast applications are as effective as anything on established stands. Split applications of P are generally not beneficial in Wyoming as they are in warmer, longer-growing-season areas.
Potassium, sulfur, iron, zinc, and boron are generally not deficient in Wyoming soils but can be deficient in certain situations. It’s worth testing soils for these nutrients at least every two to three years.

Fertilizers should be applied immediately after harvest – before regrowth begins – to avoid salt damage to leaves. Avoid driving on soft soils in the spring or after irrigation because compaction can decrease production, and root crowns are more vulnerable to damage. Topdressing fertilizer after the first cutting improves regrowth during the growing season, while topdressing after the last cutting improves winter hardiness. To avoid salt damage, split applications of more than 500 pounds per acre, and don’t use foliar sprays for moderate to high rates of N or P. Foliar sprays can be very effective for micronutrients.

Manure is an excellent source of P, K, and micronutrients, but also supplies N, which will favor grasses and weeds. Applying less than 10 tons of manure per acre application to avoid salt damage to pure alfalfa stands can increase soil organic matter and replace important nutrients.

Jay Norton is an assistant professor in the Department of Renewable Resources and is the University of Wyoming Cooperative Extension Service soil fertility specialist.