Nitrates in South Dakota Range Soils[1]

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Highlight

The nitrate contents and distributions were found to be similar in some South Dakota range soils with and without alfalfa and from over-grazed and lightly grazed range. Less than 3 ppm NO_3-N was found except for 8 ppm in shale substrata below the normal depth of moisture penetration.

Nitrates in lower layers of some Colorado soils were depleted by alfalfa (*Medicago sativa*), which has a deep root system (Stewart, et al., 1967). If nitrates accumulate in range soils, alfalfa interseeded into the range probably would cycle this nitrogen back to the soil surface. In addition, subsoil nitrates should be less abundant in lightly grazed range than in over-grazed range where the plants have shallower root systems (Jameson, 1964). The nitrate contents and distributions in some South Dakota range soils with and without alfalfa and from over-grazed and lightly grazed range will be reported.

Methods and Materials

Well-drained soils at the Antelope Range and the Cottonwood Range Field Stations were sampled. The Antelope Station is in northwestern South Dakota, has about 340 mm annual precipitation, and soil developed from Tertiary-age fine sandstones with lenses of siltstone and shale. The Cottonwood Station is in west central South Dakota, has about 380 mm average annual precipitation, and soils developed from Cretaceous-age Pierre shale. Soils at the two stations are sandy loams or loams and clays, respectively, which span the textures most commonly found in South Dakota.

At Antelope Range, several alfalfa varieties were established in 1953 after the natural vegetation was reduced by disking. Soil samples were taken in June, 1970 from location A-1 (area in low range condition used by sheep in winter), A-2 (10 m from A-1 in old Ladak alfalfa plot), A-3 (50 m from A-1 in the low condition range), and A-4 (15 m from A-3 in old plot of an experimental alfalfa variety). Soils A-1 and A-2 were from a southwest-facing, 3 percent slope of a ridge crest and Soils A-3 and A-4 were from the north-facing, 12 percent slope of the ridge. The vegetation growing on soil A-1 was mainly threadleaf sedge (*Carex filifolia*), blue grama (*Bouteloua gracilis*), and fringed sagewort (*Artemisia frigida*) with a few plants of needle-andthread (*Stipa comata*), prairie junegrass (*Koeleria cristata*), scarlet globemallow (*Sphaeralcea coccinea*), scarlet gaura (*Gaura coccinea*) and rush skeletonplant (*Lygodes-*

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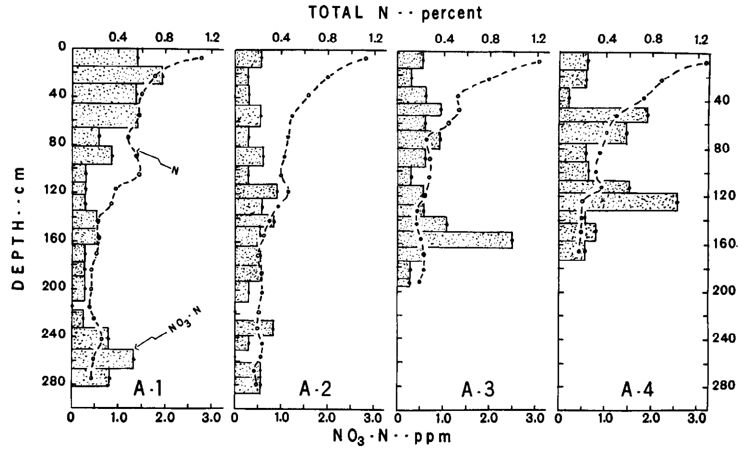

FIG. 1. Comparison of total and nitrate nitrogen distribution in soils from range (A-1), adjacent sparse alfalfa planted in range (A-2) and range (A-3), and adjacent moderately thick stand of alfalfa planted in range (A-4).

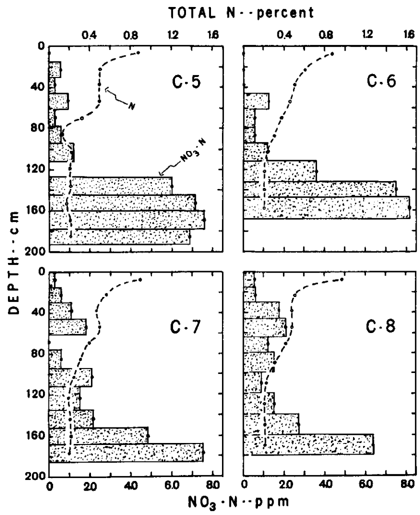

FIG. 2. Comparison of total and nitrate nitrogen distribution in soils from lightly grazed range (C-5 and C-8) and from an adjacent heavily grazed range (C-6 and C-7) at the Cottonwood Range Field Station.

mia juncea). Needleandthread and blue grama were the main vegetation of Soil A-2 which had Ladak alfalfa although the nearest alfalfa plant at time of sampling was about 2 m away. Vegetation on soil A-3 was mainly threadleaf sedge but with more needleandthread than was on soil A-1 and with some western wheatgrass (*Agropyron smithii*), fringed sagewort and silverleaf scurfpea (*Psoralea argophylla*) about 1 m away. Alfalfa plants of an experimental variety on soil A-4 had stems that spread to nearly cover the ground at sampling time although the 1 m spacing between the plants contained considerable needleleaf sedge (*Carex eleocharis*) and some small needle-and-thread plants.

At Cottonwood, soils C-5 and C-8 were 4 m apart in a good range condition pasture where use had been light since 1942. Soils C-6 and C-7 were about 8 and 12 m, respectively, from the first two soils in a poor range condition pasture which had been heavily grazed since 1942. The lightly grazed sampling area was mainly western wheatgrass with some green needlegrass (*Stipa viridula*) while the heavily grazed sampling area was mainly buffalograss (*Buchloe dactyloides*) with sparse western wheatgrass, needleleaf sedge, fringed sagewort, scarlet globemallow, six weeks fescue (*Festuca octoflora*), and Japanese brome (*Bromus japonicus*). Shale fragments became more numerous and larger in size from a depth of 1 m to 2 m where the fragments were essentially unweathered except for oxidation of the outer part of the dark-colored fragment.

Nitrates were extracted from the undried soils with 1N $CuSO_4$ and determined by the phenoldisulfonic acid method (Jackson, 1958). The NO_3-N is reported on an oven-dry weight basis while the Kjeldahl-determined total N is reported on an air-dry weight basis.

Results and Conclusions

Soils at Antelope Range Field Station had similar total N and NO_3-N contents where the vegetation was range or alfalfa or where alfalfa had been planted in range (Fig. 1). The average NO_3-N for the soils was about 1 ppm and it did not appear to be related to the total N content. The low, relatively uniform NO_3-N content with depth in the soil probably is because the subsoil rarely is moistened by water draining downward from the nitrogen-rich surface layers. A meter-thick layer of loam soil, dried previously by plants, can store about 20 cm of plant-available water (Black, 1968) before water can drain from this layer. Thus, soil moistening below a meter would be unlikely because three-fourths of the 340-mm annual precipitation comes during the growing season when it is used rapidly by plants. Nitrates would not leach from the soil where the precipitation is less than the amount needed to wet the subsoil. At the time of sampling, the soil below 100 or 125 cm had 7–12% moisture in the sandier layers which is about the amount found when plants wilt. Apparently subsoil nitrates either have not accumulated or have been removed by the deep-rooted forbs in the prairie as well as in the soils planted to alfalfa. Possibly on these soils nitrogen is needed more than water for plant growth so the NO_3-N is used rapidly and cannot accumulate in the soil.

Soils from lightly and heavily used range at the Cottonwood Range Field Station also had similar total N and NO_3-N contents (Fig. 2). The average NO_3-N content of the upper well-developed soil layers was about 1 ppm while the substratum which lacks soil development had about 8 ppm. This nitrate distribution probably is caused by the depth of moisture penetration in the soil. Nitrates are not likely to be from the shale parent material because oxidation was poor when the dark color developed. Apparently water does not or rarely enters the shale substratum or it would have more soil development. In addition, water contents in the lower soil and shale (about 20%) are those found at the wilting point. Leaching of nitrates from overlying soil into the shale cannot be excluded as a possibility. However, plant roots usually do not grow extensively in shales (Fehrenbacher et al., 1965) so the removal of the leaching water by plants is questionable. Water might move up from the shale to the overlying frozen ground in the winter. In addition, nitrates may move downward as the soil freezes. Soluble salt solutions are concentrated in fluid cavities in sea ice as it freezes. These fluid globules subsequently migrate downward as the ice warms and cools as the air temperature changes (Kingery and Goodnow, 1963). This process, if it occurs in soils, could concentrate nitrates in the substratum.

Nitrogen in the well-drained soil must be utilized rapidly by plants as it is mineralized so that high concentrations of nitrates do not accumulate irrespective of grazing intensity and presence or absence of alfalfa. Apparently the shallow water penetration in the soil would not leach nitrates below the rooting zone if abnormal conditions did cause them to temporarily acccumulate.

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