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RISKS FROM HIGH MANURE APPLICATION BEFORE PASTURE RESTORATION

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Abstract

Livestock producers are faced with difficulties in applying manure uniformly, and occasionally may be tempted to apply excessive rates in areas adjacent to farmsteads. We studied the effect of excessive manure application to a silt loam soil on a 3-acre field that was subsequently seeded to a pasture mix. Large losses of soil nitrate occurred, presumably by leaching. Grass tetany was a risk for livestock grazing grasses in the mixture. The more serious problem was forage nitrate. Three ewes died of nitrate poisoning after selective grazing during the second growing season after manure application. Although forage nitrate concentrations had fallen to an average of 1400 ppm, some weeds contained over 8000 ppm nitrate-N. Manure 'disposal' can harm the environment, forage quality, and livestock health. These results also may apply to potential problems on out-wintering sites, where excessive manure accumulates.

Introduction: Manure has the potential to be a valuable resource by improving soil quality and crop performance (Madison et al., 1995). It provides nitrogen, phosphorus, potassium, micronutrients, organic matter, and additional moisture holding capacity. Should the application of livestock manure be poorly managed, however, it can become a major pollutant to air, soil, and water sources. A field that received a large application of manure slurry and composted manure aroused our interest, as this 'disposal' of manure represented an example of a poor management practice rather than an application at recommended rates. Many farmers have limited opportunity or facilities to apply manure correctly. Land application is the most common and efficient method to utilize livestock manure. According to surveys, the cost of labor and fuel, limited availability of time, adequate storage, equipment, and accessibility of fields are important factors that restrict timely, uniform, and effective manure applications (Nowak, et al., 1998; Russelle, 1999). Many graziers have begun to keep lactating herds on small paddocks near the milking parlor, a practices called out-wintering. Our research objective was to document the impact of excessive manure applications on soil nutrient concentrations and plant response when renovating a pasture.

Materials and Methods: The research was conducted on a 3-acre site at the University of Minnesota, St. Paul. The soil is an Antigo silt-loam. In the fall of 1995, the site had been

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uniformly treated with 2600 bu composted manure/acre and 75,000 gal manure slurry/acre. Soil cores were taken with a Giddings 1-5/8 inch hydraulic soil probe in the fall of 1995, spring of 1996, and spring of 1997 to a depth of 4 to 5 feet in 76 locations. In order to broaden our ability to interpret the data, distances between sampling sites ranged from 10 to 70 feet in each of four transects across the field. An additional 12 cores were taken between those points where large gaps between sampling sites existed. As the manure application rate probably varied considerably across the field, this sampling procedure allowed us to better estimate the small scale variability of nutrient concentrations. Inorganic nitrogen was extracted from these soils using 2*M* potassium chloride and the extract was analyzed colorimetrically by flow injection. In addition, topsoil samples were analyzed for Bray-extractable phosphorus and exchangeable potassium.

In the spring of 1996, following the heavy manure application of the previous fall, the research site was tilled by disking to a 6-inch depth and then seeded with equal numbers of pure live seed of four species: 'Palaton' reed canarygrass (*Phalaris arundinacea* L.), a low alkaloid variety more palatable than older varieties; 'K31' tall fescue [*Festuca arundinacea* (Schreb) S.J. Darbyshire]; 'Norcen' birdsfoot trefoil (*Lotus corniculatus* L.); and 'Ineffective Saranac' alfalfa (*Medicago sativa* L.), a germplasm that cannot fix nitrogen from the atmosphere. The field was mowed twice in 1996, leaving cut plant material in the field. Ten randomly selected small plots (~9 ft^2) were sampled in June 1996 to estimate yield and nitrogen uptake. In mid-June 1997, ten plots (~9 ft^2) within the large field were again harvested for forage yield. After separating weed species from the seeded species, we determined yield, total nitrogen (by Kjeldahl analysis), and nitrate/nitrite in the plant tissue.

Results and Discussion: Inorganic nitrogen ranged up to 600 lb ammonium-N/acre and 700 lb nitrate-N/acre in the upper 3 feet of soil in the late fall of 1995 (Fig. 1). High concentrations of nitrate in fall can result in nitrate leaching losses before the crop can take it up in the next growing season. Soil nitrate levels increased in the topsoil between the first and second sampling (Fig. 2). This increase is probably the result of nitrification of the manure and compost, which releases nitrate-N. From the spring of 1996 to spring 1997, the soil nitrate concentrations decreased by 80 ppm in the topsoil and apparently moved deeper into the soil. In addition to plant uptake of the nitrate, losses probably occurred by leaching and denitrification. Nitrate leaching can contaminate groundwater and denitrification can release 'greenhouse' gases that may play a role in affecting climate change.

Extractable phosphorus in the topsoil ranged from 100 to 650 ppm (average was 300 ppm) and exchangeable potassium ranged from 175 to 3300 ppm (average was 1200 ppm potassium), each about 10 times the level considered 'high' by the University of Minnesota Extension Service recommendations. On sloping land there might be significant concern about phosphorus runoff into freshwater streams and lakes. By midsummer 1997, phosphorus concentrations were essentially unchanged (average 380

ppm), but potassium concentrations had declined in the top 6 inches of soil (average 900 ppm), perhaps because potassium moved deeper into the soil.

At seeding of the two perennial grasses and two legumes in spring 1996, many weedy species were present in the field, such as Canada thistle [*Cirsium arvense* (L.) Scop] and pigweed (*Amaranthus retroflexus* L.), which apparently competed with the seeded plants for moisture and nutrients, especially at the northern edge of the pasture. We did not apply herbicide to control the weeds because of the limitations due to herbicidal non-selectivity and because we planned to graze livestock, so we removed vegetative portions of the thistles by hand. The establishment of the seeded species was also slowed due to poor seedbed conditions caused by the excess application of the compost. Because of the resulting high organic matter content of the seedbed, it was not possible to achieve the evenness and firmness recommended for establishment of small seeded forage species. Forage yields in July 1996 averaged 1800 lbs dry matter/acre and average nitrogen uptake was only 75 lb nitrogen/acre.

In mid-June 1997 total yields ranged from less than 2000 to more than 5000 lb dry matter/acre across the field. Only one site was dominated by weeds; most sites had good stands of seeded grass and legumes.

Forage quality was compromised by the high manure and compost application. Very high soil nitrogen and/or potassium levels can result in forages that contain inadequate magnesium, which can cause grass tetany (hypomagnesemia). The birdsfoot trefoil and alfalfa had safe concentrations of the nutrients, however the grasses and especially the weed species contained excessive potassium in relation to calcium and magnesium at nearly all levels of soil potassium found in the pasture (Fig. 3). Grass tetany does not pose a threat to livestock if they graze both the grasses and legumes. However, in an all-grass pasture the risk of tetany increases. In addition, feed potassium in excess of 1.5% is particularly harmful to dry cows, due to the cation-anion imbalance (Howard, 1995). Alfalfa and grasses averaged 3.0-3.2% potassium, birdsfoot trefoil averaged 4.0% potassium, and lambsquarters contained up to 11% potassium in the June 1997 sampling.

In addition to the high potassium levels in the plant tissue, the high manure application rate also resulted in very high plant nitrate concentration. When pasture is the sole source of feed, nitrate concentrations in excess of 1500-2000 ppm nitrate-N can be toxic to livestock, depending on animal age, condition, and stress level. From our analysis of the plant tissue sampled in June 1997, the pasture contained an average of 1400 ppm nitrate-N, a concentration low enough to assure no problem in animal performance. However the vegetation on our study pasture varied widely in nitrate concentration across the field and among plants (Fig. 4). The legumes usually had lower nitrate concentrations than the grass. The weed species, dandelion (*Taraxacum officinale* L.), pigweed, lambsquarters (*Chenopodium album* L.), and thistle had much higher nitrate-N concentration than the seeded species. Two samples of Canada thistle had concentrations greater than 13,000 ppm nitrate-N. The forage was removed as hay in June following sampling to reduce the preferential consumption of high nitrate species.

In mid-August 1997 following two months of regrowth, the pasture was divided into three paddocks using cross fencing. Six steers were grazed in the first paddock at the west end of the field for seven days, and in addition to the nutrients they obtained by grazing, they were also fed surplus bagels as an energy supplement. Adding bagel energy to the livestock ration reduces the potential for nitrate toxicity by diluting the nitrate concentration in the rumen. After seven days, the steers were moved east to the next paddock and twenty ewes were rotated in, replacing the steers in the first partially grazed paddock.

Within a few days of the third rotation of paddocks, three of the ewes had died and four were very sick, but survived after they were removed from the paddock and fed grass hay. Autopsies confirmed that nitrate poisoning was the cause of death. Upon analysis, we determined that several factors were involved in these unfortunate deaths. First, the steers had grazed selectively, preferring the seeded species over the weeds. This left an abundance of the higher nitrate level weed species, such as pigweed and lambsquarters. Also, at the third rotation, the supplemental bagel energy source was not available to the ewes, increasing their susceptibility to nitrate poisoning.

In this experiment, our research demonstrated that the practice of manure 'disposal' does pose risks, as this practice can compromise environmental quality, animal health, forage quality, and economics. When considering the application of manure at high rates before renovating pastures, the farmer should foresee and thus avoid the possible negative consequences before grazing animals on the pasture; forages need to be tested for grass tetany potential, excessive potassium, and nitrate concentration. Putting into practice a circumspect approach to manure management can overcome the negative side effects and risks of livestock waste application to pastures and more fully utilize the beneficial effects of manure.

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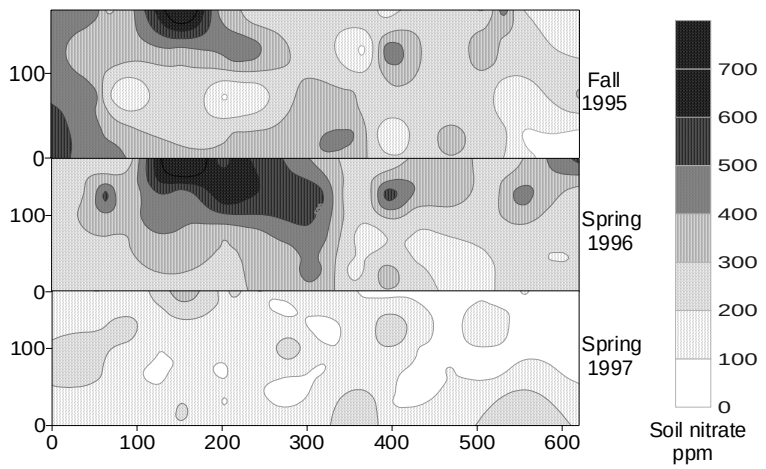

Figure 1. Soil nitrate content over time in top 36" in a 3-acre field that received excess manure in fall 1995.

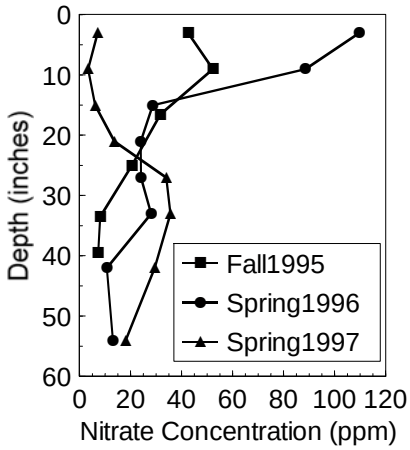

Figure 2. Soil nitrate concentration changes with depth and time.

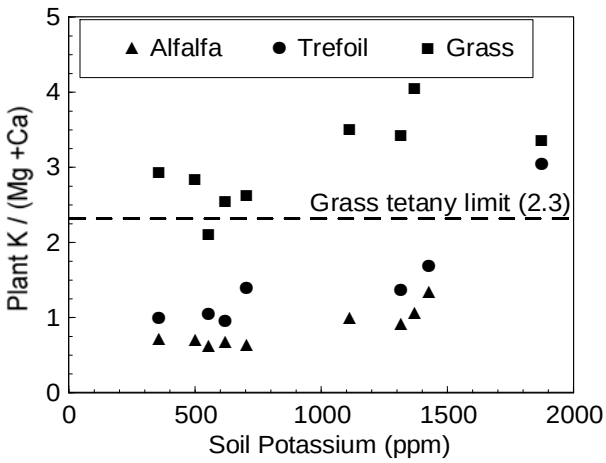

Figure 3. Relationship between soil K (ppm) and herbage K/(Mg + Ca) expressed as moles of charge.

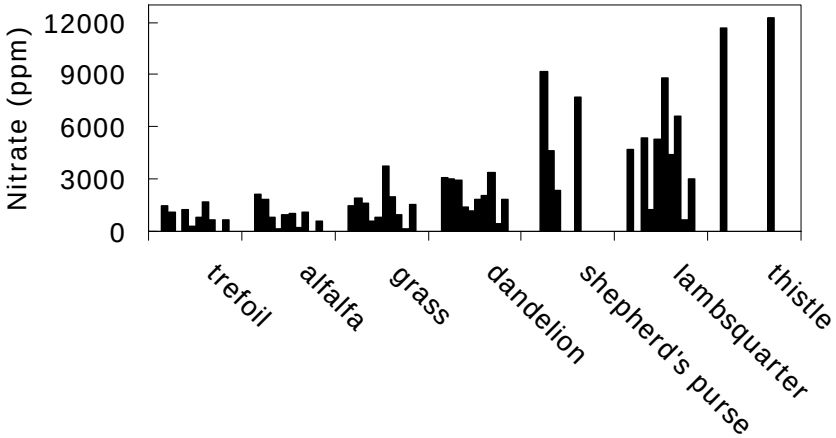

Figure 4. Nitrate concentration of herbage at ten sampling sites in a 3-acre pasture, 20 months after excessive manure application.