ALBERTA

Translocation of Surface-Applied Phosphorus and Potassium into a Grassland Soil

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Tame forage crops for grazing and hay production occupy over 11 million acres in western Canada. While much of this area receives little management attention once established, numerous research trials have shown that forage productivity can be enhanced significantly through fertilizer application. Fertilizers are generally applied to established forage stands by broadcast application on the soil surface.

> The absence of phosphorus (P) or potassium (K) accumulation below the 12-inch depth suggests that there is very little potential for deep leaching from application of P or K fertilizer to forage stands in most regions of western Canada.

Because both P and K are considered relatively immobile in soil and only a small portion of the fertilizer P and K is used by the plants in the year of application, the accumulation of these nutrients and their gradual downward movement have been observed as a result of fertilization. A review of the published scientific literature suggests that the amount and translocation depth of surface-broadcast P and K into the soil vary from one study to another. Understanding the long-term movement of P and K into different soil depths resulting from their surface applications would assist in helping to clarify any potential for surface and groundwater contamination. The objective of this study was to determine the effects of long-term use of different nitrogen (N), P and K fertilization rates on soil pH and extractable P and K concentrations in a grassland soil profile.

The field experiment was located on a Thin Black loam soil (Typic Boroll) with 9.5 percent organic matter and a pH of 6.8, in an area with a mean annual precipitation of about 18 inches and a growing season from early-May to late-September. A smooth bromegrass (*Bromus inermis* Leyss) stand, harvested for hay each year in late July, received various combinations of N, P and K fertilizer rates. The annual fertilization rates were 0, 75, 150, 250, and 300 lb N/A (as ammonium nitrate) for 30 years (1968 to 1997), in selected combinations with 0, 34, 68, 114, 136, 227, and 272 lb P_2O_5/A (as triple superphosphate) for 10 years (1968 to 1977), and with 0 and 48 lb K_2O/A (as potassium chloride) for 14 years (1984 to 1997). A zero-fertilizer control was also maintained over the 30 years of the study. The fertilizers used were surface broadcast in early spring (mid- to late-April) on the plots arranged in a randomized complete block design with six replicates. In October 1997, soil samples were taken from 0- to 2-in., 2- to 4-in., 4- to 6-in., 6- to 12-in., 12- to 24-in., 24- to 36-in., and 36- to 48-in. depths. The soil pH (1:2 soil:water mixture), P (0.03 M ammonium fluoride + 0.03 M sulfuric acid mixture) and K (1.0 M ammonium acetate) were determined on these soil samples.

Results show that pH decreased with increasing N rate, and the effect of N rate on the soil pH declined with soil depth (**Figure 1**). Only at the highest N rate of 300 lb N/A did soil pH show any change below the 4-inch depth. Extractable P concentration in the soil exhibited the effect of 10 years of P fertilization rates, even though application of P had been terminated in 1977, 20 years prior to soil sampling (**Figure 2**). The P accumulation and translocation depth increased with increasing N and P rates and with a decline in the soil pH. Accumulation in the surface soil depths at high N rates was attributed to N-induced acidification, making soil P more soluble. Most of the P accumulation from surface-applied P fertilizer occurred in the top 4-in. soil layer, and almost no accumulation was recorded below the 12-in. depth.

Surface-applied K prevented N-induced K depletion from the top 36-in. soil layer (**Figure 3**). While only a small accumulation of K was observed in the 4- to 12-in. soil layer, 48 lb K_2O/A per year appears to have achieved a balance between K addition and bromegrass removal of K. The absence of P or K accumulation below the 12-in. depth suggests that there is very little potential for deep leaching of these nutrients. However, where high N rates were combined with P application, P accumulation occurred in the surface soil, and this could increase the potential for P loss in surface water runoff, especially on breaking of the forage stand.

In western Canada, the wide-scale adoption of no-till breaking of forages using herbicides has helped to reduce the amount of tillage required to prepare a seedbed for the next crop in rotation. If herbicide termination of forages were combined with no-till seeding of annual crops, any potential for loss of surface accumulated nutrients could be minimized.

Bromegrass forage yields from this study indicate that the crop responded positively to fertilizer N applications, with minor yield response to K fertilization, and little or no yield response to P additions. As referred to earlier, the solubilization of soil P with fertilizer N additions appears to have met the hay crop requirements. An economic analysis of the N response data revealed that the optimum N rate for bromegrass hay production in this region of Alberta was 100 lb N/A, when evaluated over a broad range of fertilizer costs and hay prices. As a result, farmers fertilizing their hay at or below these economic N rates can expect to have a minor impact on soil pH levels and accumulation of soil P in the surface 0 to 2 inches. BC

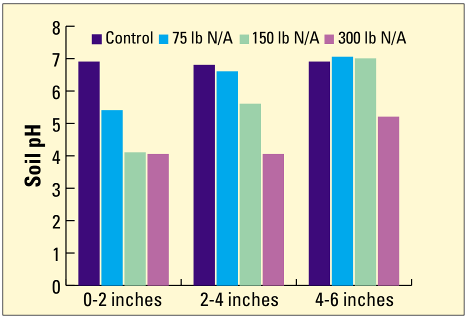

Figure 1. Soil pH as influenced by different rates of N applied for 30 years (no P or K was applied).

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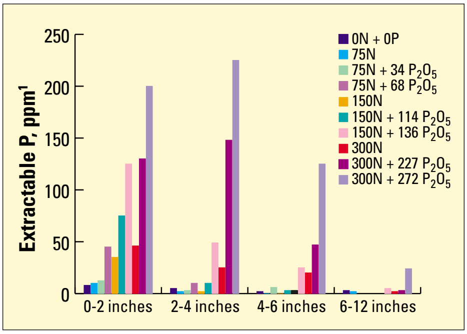

Figure 2. Soil extractable P as influenced by different rates of N applied for 30 years (1968-1997) and P for 10 years (1968-1977).

[1]parts per million

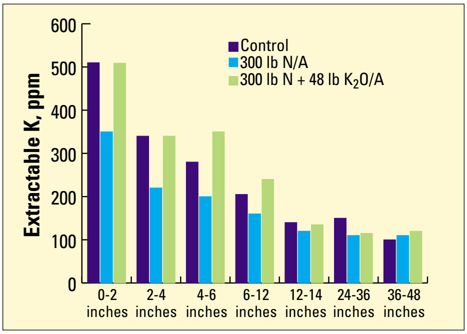

Figure 3. Soil extractable K as influenced by different rates of N applied for 30 years (1968-1997) and K for 14 years (1984-1997).