International Section

SOUTHERN LATIN AMERICA

Potassium Surface Runoff and Leaching Losses in a Beef Cattle Grazing System on Volcanic Soil

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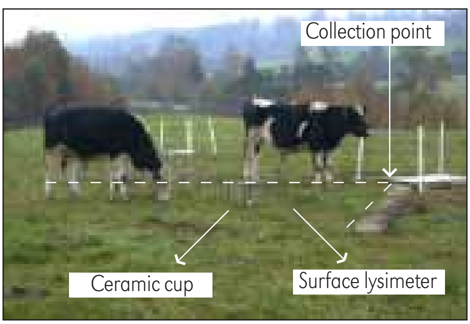
This article presents results of a study on potassium (K) losses through runoff and leaching in permanent pastures under beef production on volcanic soil in southern Chile. Losses due to runoff and leaching were low (4 kg K/ha/yr, on average), with 94% of the losses due to leaching. Increases in the stocking rate did not increase K losses.

Nutrient runoff from agricultural lands is generally considered a contributor to non-point surface water pollution. Chilean livestock production is concentrated in the southern part of the country and is largely based on a direct grazing system that has intensified over the last 10 years because of new commercial trade agreements signed by the country. This more intensive land use has increased amounts of nitrogen (N), phosphorus (P), and K fertilizer used per area, as well as the stocking rates and the intensity of rotational grazing.

Potassium losses from livestock grazing systems have been only partially studied, because of the lack of environmental impact from these losses. Nevertheless, K losses from grazed areas may represent a decrease in soil fertility over time, and thus an economic loss to farmers. The objective of this work was to quantify K losses in surface runoff and leaching from permanent pastures grazed with different stocking rates.

Potassium losses were evaluated in a closed beef cattle production system based on grazing at National Institute for Agricultural Research (INIA) Remehue (40º 35' S 73º 12' W), between March and December 2005. The soil at the experimental site is a volcanic andisol from the Osorno soil series (Typic Hapludands), which has 6% slope, more than 1 m of depth, high organic matter, and high K concentrations (**Table 1**). The 30-year average rainfall for the area is 1,284 mm/yr.



View of a surface lysimeter and ceramic cups used for the study of K losses in the beef cattle grazing system.

Stocking rates tested were 3.5 and 5.0 steers/ha, with an initial animal live weight of 212 ± 9.9 kg/animal (Holstein Friesian). Paddocks were divided into 45 strips and animals were managed under rotational grazing (one new strip every day) on a permanent pasture that had been continuously used for grazing with beef cattle for 20 years.

Table 1. Soil chemical analysis (0 to 20 cm) for the stocking rate treatments at the beginning of the experimental period, Feb. 2, 2005 (n=2, ± sem[1]).

Property	3.5 steers/ha	5.0 steers/ha	Category
Olsen P, ppm[2]	37.0 ± 11.6	28.0 ± 6.9	High
pH water	5.8 ± 0.05	5.7 ± 0.02	Slightly acidic
Organic matter, %	19.0 ± 3.5	15.0 ± 1.0	High
K, cmol(+)/kg, (ppm)	1.3 (507) ± 0.72	1.5 (585) ± 0.38	Very high
Ca, cmol(+)/kg, (ppm)	6.9 (2,760) ± 1.47	6.7 (2,680) ± 0.56	Intermediate
CEC, cmol(+)/kg	10.1 ± 2.61	10.0 ± 1.17	Intermediate
Sulfate-S, ppm	11.0 ± 0.4	12.0 ± 2.2	Intermediate

[1]sem = standard error of the mean. [2]ppm = parts per million.

Fertilizer treatments included 68 kg N/ha (45 kg in autumn and 23 kg in spring as sodium nitrate) and 69 kg P_2O_5/ha (in spring as triple superphosphate). No K fertilizer was added. These amounts and timings of fertilizer application represent a traditional management for beef farms in the area.

To quantify K losses in surface runoff, three surface lysimeters (5 x 5 m) were established in each treatment. Surface runoff samples were collected three times per week from the surface lysimeters between April 1 and December 15. Runoff samples were stored at 4 °C until analysis for available K by atomic absorption spectrophotometry within one week of collection. The accumulated surface runoff was measured at each sampling date with the use of a graduated collector.

Three surface lysimeters were established at each treatment.

To measure K leaching losses, three ceramic cups were installed in each surface lysimeter at 60 cm depth. The sampling was carried out with every 200 ml of drainage between May 6 and August 31. Collected samples were frozen at minus 10 °C until analysis. The volume of drainage lost by leaching was estimated as the difference between rainfall and evapotranspiration, once surface runoff was discounted.

Total K losses in surface runoff and leaching were calculated as the product of drainage and K concentration in the respective samples for each pathway, and then totals were added at the end of the season.

Analysis of variance was used to compare K concentrations and losses between treatments.

Results and Discussion

Total rainfall for the experimental period was 1,317 mm and total drainage below 60 cm was 941 mm. The main pathway for water movement was leaching, with no significant differences between treatments ($p = 0.05$; **Table 2**).

Average K concentration in surface runoff samples was greater than that of leachate samples (**Table 2**), because of the direct effect of urine transport in surface runoff samples. The dynamics of K concentration in surface runoff samples over time was not different between treatments ($p = 0.05$), but K concentration increased immediately after grazing and during spring time (September). This was also related to the urine transport in surface runoff, which has a high K concentration, and probably because of the increase in organic matter and fresh resi-

Table 2. Drainage (% of total drainage), K concentration in surface runoff and leachate samples (mg/L), and total K losses (kg/ha) in paddocks with different stocking rates (± sem[1]).

	3.5 steers/ha	5.0 steers/ha
Drainage		
Surface runoff	1% a	1% a
Leaching (> 60 cm)	99% a	99% a
K concentration (range), mg/L		
Surface runoff samples	22.0 ± 2.38 a (3 to 125)	23.0 ± 2.83 a (1 to 138)
Leachate samples	0.49 ± 0.04 a (0.05 to 1.47)	0.30 ± 0.02 b (0.1 to 0.89)
Total K losses, kg/ha		
Surface runoff	0.2 ± 0.009 a	0.2 ± 0.005 a
Leaching	4.7 ± 1.47 a	2.8 ± 0.24 a
Total	4.9 a	3.0 a

Different letters between columns indicate significant differences (p = 0.05).
Total rainfall for the period was 1,317 mm and total drainage collected for the period was 941 mm.
[1]sem = standard error of the mean.

due decomposition during spring, which increased K availability in the soil. Average K concentration in leachate samples was less than 1 mg/L, which is low for grazing paddocks, probably because this element was not added as fertilizer.

Similar to water movement, the main pathway for K loss was leaching (94%, on average). Losses in surface runoff were low because of the low amount of surface runoff generated by this soil type due to high infiltration and water holding capacity.

Total K losses were low (3 to 5 kg/ha/yr), again probably because no K was added as fertilizer. Other studies carried out on volcanic soil have found losses between 9 to 19 kg K/ha/yr. These studies attributed the occurrence of preferential flow as the main pathway for K loss, which was not observed in the present study.

The amount of K recycled onto the soil by the grazing animals can be estimated as 62 and 77 kg K/ha/yr, for the 3.5 and 5.0 steers/ha treatments, respectively. Thus, K losses represented only 6% of the K deposited in the soil by animals. In grazed areas where the pasture is also harvest for silage, K removal can reach 84 kg K/ha/yr. In this case, K should be added as fertilizer to correct the expected negative soil K balance produced by plant uptake/removal and K losses due to runoff and leaching.

Conclusions

This intensive beef cattle production system in southern Chile, based on grazing a volcanic ash soil, had little K loss via runoff and leaching (4 kg K/ha/yr, on average). In total, 94% of the losses were a result of leaching. An increase in the stocking rate did not have an impact on K losses from the system. Further research is required to complete this study as high variability between grazing paddocks and variable rainfall distribution between years may alter these conclusions. BC

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