SNOW MANAGEMENT IN THE RECLAMATION OF SODIC SOILS

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THE SODIC SOIL PROBLEM

Sodic soils contain an excess of exchangeable sodium relative to other cations. This imbalance can lead to the separation and dispersion of soil aggregates into smaller particles and, if the imbalance is severe, causes swelling of soil clays. These processes alter soil structure and reduce its permeability to water and air. Exchangeable sodium percentages are difficult to determine, and therefore, are often inferred from the more readily obtained sodium adsorption ratios, SAR

$$SAR = Na^{+} / [(Ca^{++} + Mg^{++} /2)^{0.5}]$$

with each ion concentration expressed in me/L (USDA Salinity Lab. Staff 1954). SAR values can be calculated using concentration data derived from ionic analyses of samples from water, soil solutions, and vacuum extracts of water-saturated soil. The ease with which soils are degraded and water movement inhibited by high SAR values diminishes as the ionic concentration of the soil solution increases. Consequently, the electrical conductivity (EC) of sample solutions, which indicates total concentration of dissolved cations, is commonly measured.

Sodicity often affects the rate at which water moves into and within a soil. Ayres and Westcot (1985) suggest that rates of three mm/hour are considered low, while 12 mm/h is relatively high. A reduced percolation rate through sodic layers within the soil profile will eventually control the infiltration rate for water continually applied at the soil surface. Researchers generally agree that permeability and soil stability relationships will be affected in non-saline soils with SAR values of 15 or more (Ayres and Westcot 1985).

IS SNOW MANAGEMENT AN ANSWER?

Remedies which seek to reverse the effects caused by sodic soils commonly involve the addition of compounds which release calcium ions to replace the excess sodium in the soil (Fireman and Branson 1965). Improvements can be expected if the amendment increases the soluble calcium content or causes a significant increase in the EC of the soil solution. The rate at which calcium ions become available depends on the solubility of the amendment. Gypsum ($CaSO_4$) is less soluble than calcium chloride ($CaCl_2$). Both compounds have been applied to reclaim sodic soils.

Calcium amendments added to the soil also require water to solubilize the calcium, to transport the calcium to the sodium, and to leach the freed sodium replaced by the calcium. Where possible, the water is supplied by irrigation. Unfortunately, many sodic soils can not be irrigated, and the availability of water limits reclamation. The objective of the study reported here was to determine if the reclamation of sodic soils in semi-arid southern Saskatchewan could be advanced by controlling snowcover accumulations to augment water from natural precipitation for calcium amendments.

EXPERIMENT

A site with severely sodic agricultural soil of clay loam texture, located near Cadillac, Saskatchewan, (Lat.49°40', Long.107°40') was chosen for the field experiment. The test consisted of three treatments: (1) calcium amendments with snowfence (CaF); (2) calcium amendments without snowfence (Ca); (3) neither calcium amendments nor snowfence. Four replications of the three treatment plots per replicate were selected within a 130 ha field agriculturally abandoned because of sodicity. Replicates were separated by 50 m or more, and formed by plots set at least 18 m apart within each replicate. The snow-fenced plots were positioned such that they would be comparable in terrain and wind fetch, and that they would not interfere with other plots especially when fronting the prevailing northwest winds that transport snow.

The plots were prepared in October 1989 by constructing low dikes from 10 cm tall plastic lawn edging stretched two m on a side resulting in areas of four m^2 each. Two plots per replication received a five-cm "irrigation" containing dissolved $CaCl_2$ supplied from a brine well by KORMAC Chemicals and applied at an areal rate of 0.9 t Ca/ha. A top-dressing

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Paper presented at the 60th Annual Meeting of the Western Snow Conference, Jackson, Wyoming.

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of $CaSO_4.2H_2O$ (1.8 t Ca/ha) in powder form (phosphogypsum supplied for the experiment by Western Coop Fertilizers) was hand-spread over the surface of the calcium plots. The third plot in each replicate was left as the untreated control, receiving neither calcium amendments nor snowfence. Tensar Polytechnologies Inc. provided the snowfencing which was fabricated from UV-resistant plastic, patterned with 45% porosity, and designed specifically for snow control. A 60-cm wide strip of fencing was hung 15 cm above the land surface on steel pickets outlining the perimeter of each snow-managed plot.

Snowcover magnitudes, soil water enrichments, rates of infiltration, and changes in the sodicity were measured at selected times during two years following application of the calcium amendments. Snowfalls during the 1989-90 winter were insufficient to warrant any snow measurements, but the winter of 1990-91 required December and March snow surveys. Snow depths (10 or more per plot) were measured with a ruled rod and averaged for each plot. These were combined with average snowcover density measurements from snow cores taken with a MSC sampler (39.1 cm^2 cutting area), obtaining average water equivalents per plot. Soil water, SAR and EC determinations were made following standard soil sampling and laboratory procedures (Page et al. 1982). Double-ring infiltrometers (39 cm outer and 20 cm inner rings) with a 2-3 cm hydraulic head provided comparable water intake rates between the plots.

RESULTS

The average volume of snow covering the CaF, Ca and N treated plots on March 8, 1991, equalled 76, 11 and 8 mm, respectively. The 65 mm of water equivalent attributed to snowfencing represents about 22 % of the districts's average annual precipitation of 300 mm. The snow water contribution to sodic soil reclamation for the 1990-91 season based on the March 8th water from snowcover enhancement plus the natural accumulation totalled 27 % of the May, June and July rainfall (280 mm). The actual fraction was, no doubt, larger because of additional light snowfalls in March and April, and because evaporation would have been much less from the snowmelt than from the rain water.

We recognize that snow retention within a small snow-trap in an open field would not necessarily represent the average snowcover accumulation in a fully-fenced field. The snowcover retention capacity of the fenced field would be much greater than that of the small plots, and would, on average, result in less snow per area fenced. Nevertheless, comparisons of the snowcovers between treatments in the small plots would still demonstrate the potential for supplementing water from snow resources.

Soil water percentages calculated by weight for Rep. 3 are shown in Figure 1 for gravimetric samples taken from sequential layers to 60-cm depths in May and June, 1991. Based on fall 1990 sampling for soil water (data not shown), all chemically-treated, snow-fenced plots received a water recharge to the 60-cm depth. The water in the non-fenced, Ca-amended plots percolated to shallower depths than in the fenced-plots. The untreated plots, lacking neither amendment nor fence, registered soil water enrichments to even shallower depths. Total soil water volumes within the top 60 cm measured on May 10th equalled 144,102 and 64 mm averaged for the CaF, Ca and N treatments.

The SAR data derived from soil cores obtained near the end of June 1991 are plotted according to depth in Figure 2. Average SAR values of the upper 30 cm of the soil exceed 15 except for top 5 cm of the snow-fenced treatment, suggesting that infiltration rates will still likely be low on all plots. Calcium treatments appear to have decreased SAR, especially where followed with snowfencing. This concurs with the observation that soil waters from winter-spring precipitation and from snow-managed supplements penetrated deeper into the soil profile under calcium and snowfencing.

Double-ring infiltration tests with surface-ponded water typically show decreasing rates of water entry with time at the soil surface. After a few hours, the rates usually reach a steady value, called the final infiltration rate, which reflects the control imposed by the soil. The rate that creek water (EC = 0.7) dS/m) infiltrated the Cadillac sodic soil before reclamation quickly reached steady state ending with final values between zero and 1.5 mm/h. Infiltration rates measured on all plots in October 1991, as exemplified by Rep. 3 in Figure 3, indicate that the calcium treatments had marginally improved the physical condition of the sodic soil. Final infiltration rates for the Ca-treated soil in all the replicates averaged 2.4 mm/h compared to 1.0 mm/h for the untreated plots. Although final rates did not statistically differ between the snow-fenced and the non-fenced calcium plots, steady infiltration rates took longer to establish and initial intake volumes were 40 mm greater following snow management. This implies that although the snowfencing lowered SAR significantly (Figure 2) and allowed snow melt and spring precipitation to penetrate deeper into the soil, sodic conditions remained severe enough to maintain relatively low final infiltration rates.

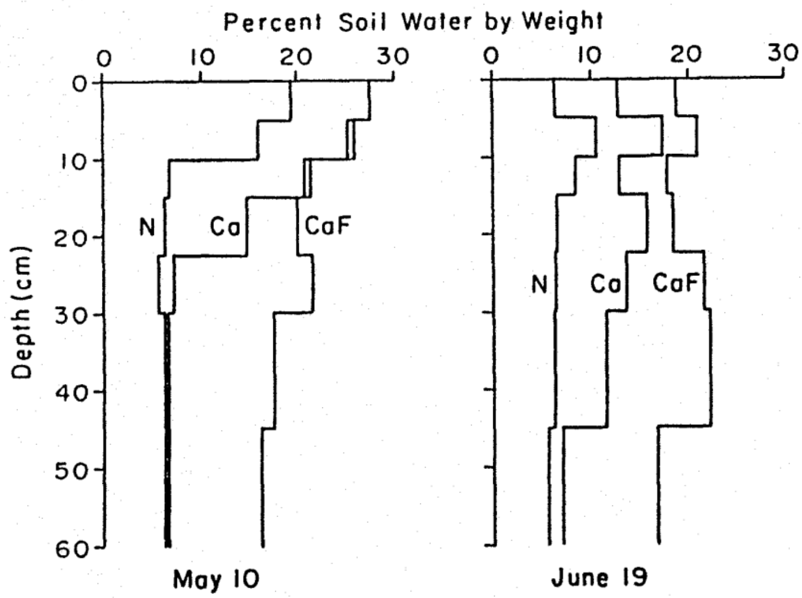

Figure 1. Soil water percentages by weight for depth layers in calcium-treated and snowfenced plots (Rep. 3) containing sodic soils, sampled on May 10 and June 19, 1991, near Cadillac, Saskatchewan.

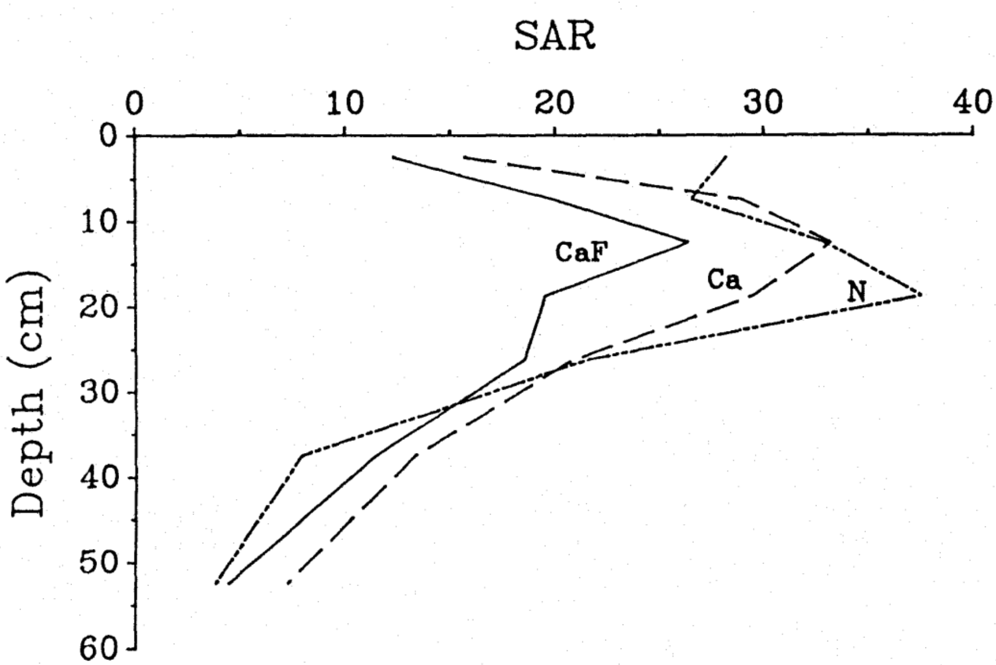

Figure 2. Sodium adsorption ratio (SAR) plotted with soil depth and determined from cores taken June 19, 1991, in plots treated with: calcium plus snowfence (CaF), calcium without fence (Ca), and neither calcium nor fence (N).

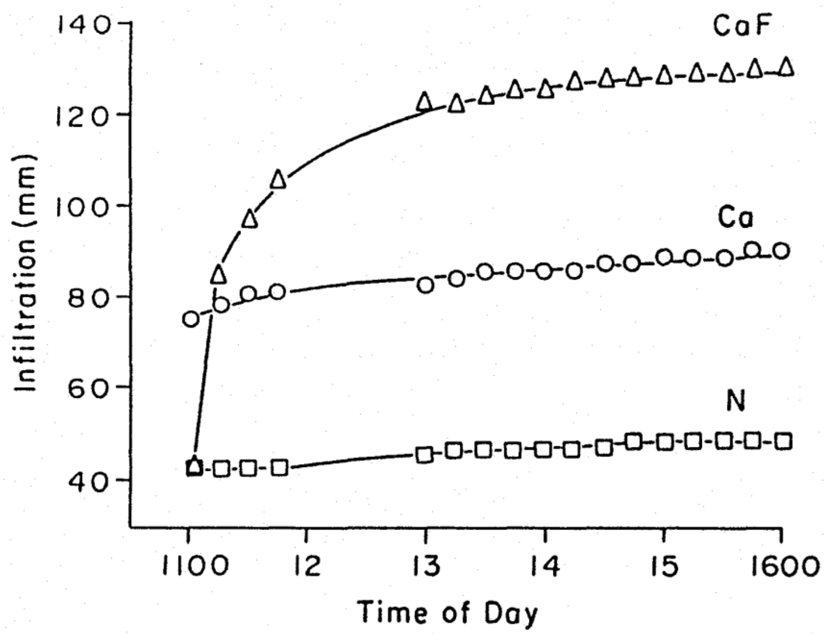

Figure 3. Measured infiltration rates plotted with time determined from double-ring tests (October 7, 1991) using creek water (Ec = 0.7 dS/m) on sodic soils near Cadillac, Saskatchewan, treated with: calcium plus snowfence, (CaF), calcium without fence (Ca), and neither calcium nor fence (N).

CONCLUSIONS

Augmenting snowcover by erecting 60-cm plastic (Tensar) snowfencing over a sodic soil in southern Saskatchewan treated with KORMAC $CaCl_2$ and phos-gypsum led to the following conclusions:

1. Snow management can deliver significant quantities of supplemental water with the potential for increasing the efficacy of calcium amendments and advancing the reclamation of sodic soils.

2. The reclamation success associated with snow management depends on the availability of snow, the severity of the sodicity, the form and amount of the calcium amendments, and the water volumes contributed by rainfall and irrigation.

3. Suggestions for future reclamation of this type include: mechanical incorporation of gypsum into the soil to improve dissolution, and establishment of perennial vegetation to utilize the additional and deeper soil water obtained from the snow management.

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ACKNOWLEDGEMENT

The authors thank Messrs. K. Wall, K. Deobald and T. Braun for the field work and Mr. G. Winkleman for lab analyses, and acknowledge financial support from the Canadian-Saskatchewan Agreement on Irrigation Based Economic Development.