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SOILS AND FERTILIZER

Effect of Simulated Acid Precipitation on Composition of Percolate from Reconstructed Profiles of Two Northern Ontario Forest Soils. — The purpose of this interim report is to compare products of leaching, chiefly bases, hydrogen (H^+)-ion and sulphate (SO_4^{2-})-ion, from two northern Ontario forest soils in columns subjected to different regimes of artificial acid loading under greenhouse conditions.

Two soils, both acid sands, were subjected to four dilute sulphuric acid (H_2SO_4) loadings, with three replications, for a total of 24 columns. Both soils were from mid-aged jack pine (*Pinus banksiana* Lamb.) forest: one sample from Wells Township, Ontario, a Humo-Ferric Podzol (Canada Soil Survey Committee, Can. Dep. Agric. Publ. 1646, Ottawa, 1978) developed in coarse glaciofluvium; and the other from Dupuis Township, 135 km to the north, a Dystric Brunisol, likewise in coarse sand. The samples were contained in columns made of acrylic plastic, foil-wrapped to exclude light, and were set on perforated lysimeter plates, each with a collecting arrangement. The cross-sectional area of each column was 161.3 cm² and the height 100 cm. Thin layers of glass wool and sieved, washed perlite were inserted at the bottom of the columns to facilitate drainage. Profiles were reconstructed as follows: lower mineral horizons (Wells: Bf, BC, C; Dupuis: Bm, $IIBm_2$, C) were air-dried, coarse-screened through a 7.7-mm mesh, then placed in the columns in appropriate order and thicknesses. The LFH and Ae horizons were excavated intact, trimmed to size, and inserted in the column tops. All columns were leached several times with distilled water to expedite settling.

The pH values of the test solutions, consisting of distilled water (control), 0.0001 N, 0.001 N, and 0.01 N H_2SO_4, were respectively 5.7, 4, 3, and 2. Volume was adjusted to the equivalent of 1000 mm per annum delivered in equal weekly, 1–2 h "events" by a drip-feed system. Columns drained freely by gravity; percolates were recovered weekly (usually by the following day), and volume, pH (by glass electrode), and specific conductivity (by Radiometer Type CDM 2e conductivity meter) were measured on each. Percolate samples were retained for SO_4^{2-} and cation analysis every 4th wk. Sulphate was determined by the barium chloride titrimetric method (Analytical Methods Manual, Inland Waters Directorate, 1979), and major cations, potassium (K^+), sodium (Na^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}), by flame emission or atomic absorption spectrophotometry (Pye-Unicam SP1900 Atomic Absorption Spectrophotometer).

On average, approximately 80% of the volumes added were recovered as percolate. Regardless of the pH of input solution, the pH of percolates has remained high (*ca* pH 7.3 declining to *ca* pH 6.5) over 3 yr of leaching,

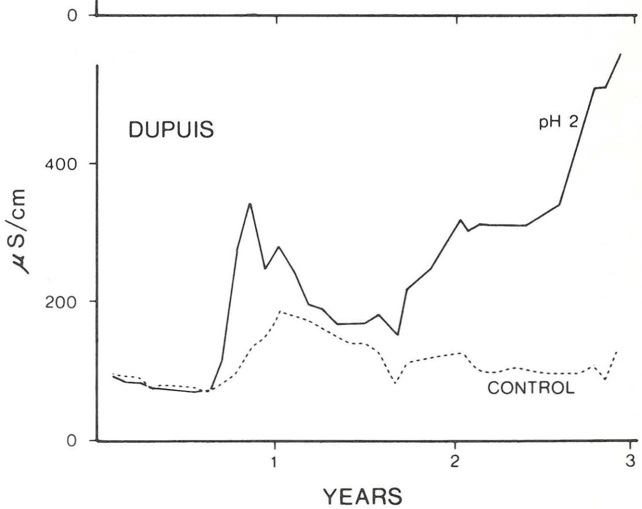

Figure 1. Conductivity (μS/cm) of Dupuis and Wells soil percolates, control and pH 2 treatments only, over 3 yr.

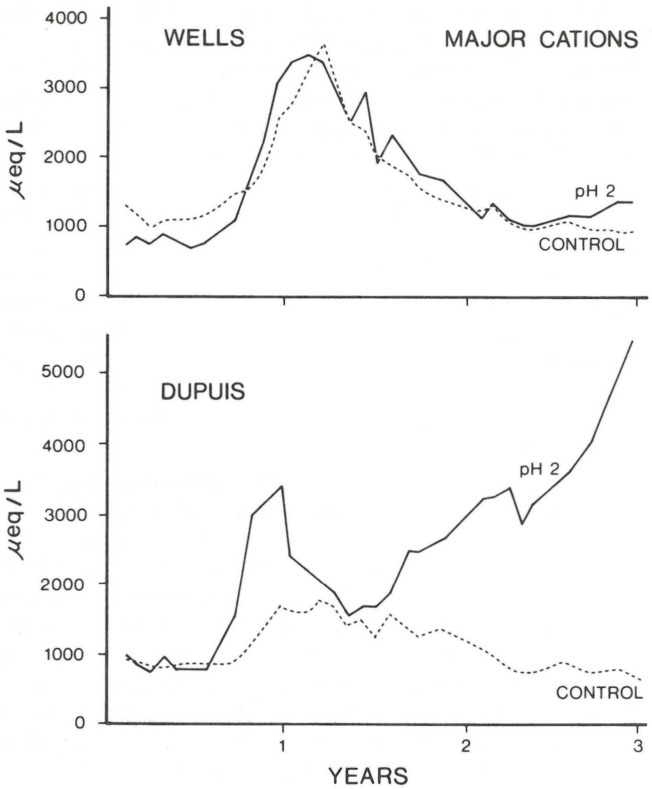

Figure 2. Cation (K^+, Na^+, Ca^{2+}, Mg^{2+}) total charge (μeq/L) in Dupuis and Wells soil percolates, control and pH 2 treatments only, over 3 yr.

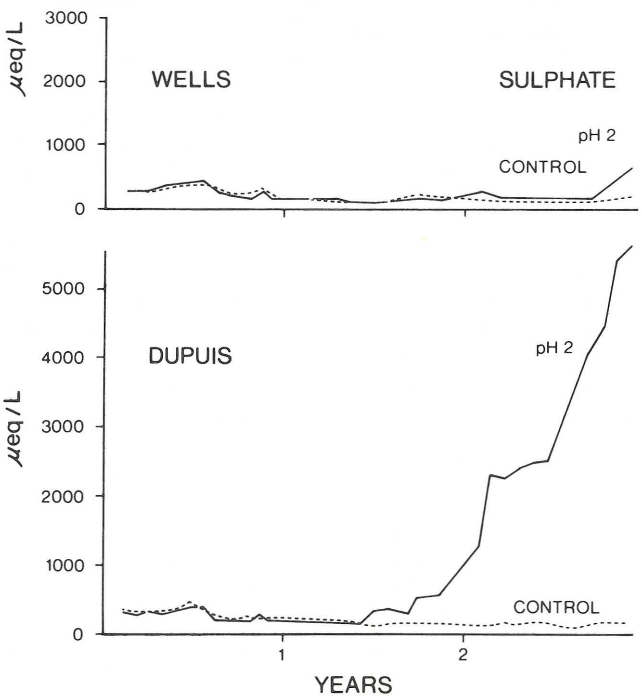

Figure 3. Sulphate concentration (μeq/L) in Dupuis and Wells soil percolates, control and pH 2 treatments only, over 3 yr.

with no apparent treatment-related differences. The fate of the added H^+-ions has not yet been determined. Because the pH 2 treatment was the only one yielding results differing markedly from those of the control, up to the time of writing, graphical comparisons are confined (for clarity of presentation) to pH 2 and control only.

At the outset, mean specific conductivity (Fig. 1) of the percolate varied slightly between soils, but not between treatments. At approximately 10 mo (i.e., summer of 1978) conductivity of the percolates from all lysimeters increased abruptly in all treatments. There was some suggestion of treatment-related difference, at least in the Dupuis soil, perhaps by greater acid hydrolysis of humic compounds. However, by approximately 20 mo, conductivity decreased to earlier levels. In the Dupuis soil subjected to the pH 2 loading, percolate conductivity again increased after the 20th mo; a similar pattern was detected for the Wells soil pH 2 treatment, after about 30 mo. Major cation concentration (Fig. 2) by cation summation generally followed the pattern of conductivity. Regardless of SO_4^{2-} input, initial SO_4^{2-} output remained low (Fig. 3) and differed little between treatments. After approximately 20 mo for the Dupuis soil and 30 mo for the Wells soil, percolate from the pH 2 treatment showed increasing enrichment with SO_4^{2-}-ions.

An approximate electrical charge composition of the percolate for week 152 is presented in Table 1.

Among the cations, the charge is dominated by Ca^{2+} with lesser contributions by K^+, Mg^{2+} and Na^+, although the percolates from the two soils differed considerably in this respect. Other cations, also measured, notably H^+, Mn^{2+}, Zn^{2+}, and Al,

TABLE 1

Electrical charge composition of percolate, week 152 (means of 3).

	Positive (μeq/L)						Negative (μeq/L)	
Treatment	K^+	Na^+	Ca^{2+}	Mg^{2+}	Other	Total	SO_4^{2-}	Other
				WELLS				
Control	36	151	740	50	17	994	229	765
pH 4	41	120	672	49	14	896	224	652
pH 3	45	220	745	73	15	1098	152	946
pH 2	42	214	872	204	16	1348	527	821
				DUPUIS				
Control	13	104	422	174	14	727	146	581
pH 4	16	107	446	183	13	765	152	613
pH 3	12	111	399	165	14	701	277	424
pH 2	42	235	3722	1474	31	5504	5427	77

contributed only small amounts to the charge composition at this point, although there was some suggestion of a slight increase in the Dupuis-pH 2 percolate. The sum of positive charges was equated to the sum of negative charges, and the contribution of

SO_4^{2-} was deducted from the latter for the purpose of calculating a residual negative charge. This negative charge differs between soils but not between treatments within soils, except for the Dupuis–pH 2 series. This residual value probably represents natural background production of organic and, possibly, some bicarbonate anions. Under the pH 2 treatment, a substantial portion of the cation movement, especially through the Dupuis soil from the 20th mo onward, is seen to be under the influence of artificially supplied SO_4^{2-}.

Initially, the soils of this study exhibited considerable resistance to acid input: 20 mo of intense loading were needed to produce a treatment-related effect. Furthermore, the soils varied considerably in this respect. A possible explanation is that SO_4^{2-} was adsorbed onto sesquioxide surfaces in the B-horizon, as was proposed by Johnson and Henderson (Soil Sci. 128:34–40, 1979) for well-weathered soils in Tennessee, or by Singh et al. (Soil Sci. Soc. Amer. J. 44:75-80, 1980) for podzolized soils in Norway. Such adsorption might serve as a protective mechanism in soils used in the present experiment as well. Indirect evidence for this hypothesis comes from the fact that the less developed (Dupuis) soil was not as resistant as the more developed (Wells) soil. Hence, SO_4^{2-}–adsorptive capacity, or some estimations thereof, may be useful as an indicator of soil sensitivity.

The rate-limiting role of anion movement in cation leaching from these soils was made evident in two ways. First, midway through the period, cation output from all columns increased substantially over all treatments, contemporaneously with partial decomposition of the moss layer, suggesting a removal facilitated by a flush of organic anions. Second, when SO_4^{2-} moved freely (Dupuis, in the 20th mo; Wells, from the 30th mo), accelerated cation leaching was resumed.

The results of the experiment suggest a stage by stage process of element loss: first, a stage wherein soil exhibits considerable resistance that, in these particular soils, is probably related to SO_4^{2-}–retention; second, a stage of cation removal under the influence of freely moving SO_4^{2-}. In the present experiment, this second stage has been reached, but only at the highest loading level. It is postulated that essentially similar processes take place under natural conditions and that resistance in these soils is a function of SO_4^{2-}–adsorptive capacity. Under the conditions of the experiment the top 100 cm of the Dupuis soil failed to retain SO_4^{2-} when the cumulative input reached the equivalent of *ca* 800 g SO_4^{2-}/m^2; equivalent total load–till–failure for the Wells soil was 1200 g SO_4^{2-}/m^2. — I.K. Morrison, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

PATHOLOGY

Effects of Inland Spruce Cone Rust, *Chrysomyxa pirolata* Wint., on Seed Yield, Weight, and Germination. — Inland spruce cone rust affects stands throughout British Columbia (Ziller, The tree rust of western Canada, Can. For. Serv. Publ. No. 1329, 1974), and recently it was observed on about 30% of the cones in a young white spruce (*Picea glauca* [Moench] Voss) seed orchard in the southern interior of the province. In natural stands, the severity of the disease on cones usually has been rated qualitatively as light, abundant, or epidemic (Ziller, loc. cit.). In 1976, cone rust ratings were quantified by localities in British Columbia (Annu. Rep., Forest Insect and Dis. Surv., Can. For. Serv. page 86, 1976) for specific localities, stands, or trees. With the exception of Nelson and Krebill's work (Phytopathology 60:1305, 1970) with blue spruce (*P. pungens* Engelm.) no data are available on the disease's effect on seed yield and germination capacity. This study was conducted to obtain the necessary information on cone collections from natural stands and to determine the need for cone rust control in spruce seed orchards.

During late August and early September in each of 3 yr (1978-1980), 10-20 pairs, i.e. one rust-affected and an adjacent healthy cone, of white spruce cones were collected from one to three trees at each of several British Columbia localities (Table 1). The hand-picked cones were placed individually in paper bags and brought to the laboratory where they were air dried at 20° C, whereupon the seeds were removed by hand. Radiography was used to distinguish empty seeds from filled ones and the latter were counted. The filled seeds from each cone were soaked overnight in water and germinated according to the International Seed Testing Rules (Anon., Seed Sci. and Technol. 4(1):1-186, 1976). To determine the disease's effect on seed weight, 15 filled seeds from each cone of the 20 pairs collected at Skimikin in 1978 were weighed following storage over water for 4 days and then over 40% (v/v) H_2SO_4 for 3 days to equalize seed moisture content (Edwards, pers. comm.). The significance of mean differences within the various parameters was determined, using a paired t-test (Steel and Torrie, Principles and procedures of statistics, McGraw-Hill Book Co., Inc., New York, 1960); the 1979 data required transformation, $\sqrt{X + .05}$, to correct for heterogeneity of variance.

Table 1 gives the yield and germination of seeds from rust-affected and healthy cones and shows that the disease significantly reduced seed yield in all cases except in the 1978 sample from Skimikin. The reduced number of filled seeds was attributable to failure of seeds to form rather than presence of empty seeds. The low seed yield from diseased cones makes comparisons of seed germination difficult, but where seed yields were not so drastically different, e.g., in the 1979 sample from Dawson Creek, germination capacity of seeds from diseased cones was significantly lower. Although germination percentages for seeds from rust-affected and healthy cones in the 1978 Skimikin sample were not significantly different, about half of the germinants from diseased cones were abnormal, with both the radicle and cotyledons emerging from the micropyle end of the seedcoat. It was the only time that this abnormality was observed. The data obtained in 1978 from cones collected at Skimikin showed that individual seeds from diseased cones weighed significantly ($P = .05$) less than