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TB126: Vertical Trends in the Chemistry of Forest Soil Microcosms Following Experimental Acidification

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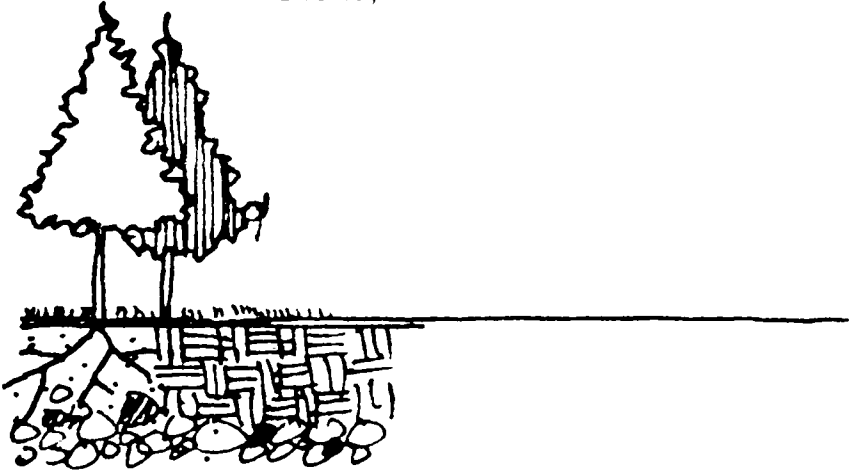
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VERTICAL TRENDS IN THE
CHEMISTRY OF FOREST SOIL
MICROCOSMS FOLLOWING
EXPERIMENTAL ACIDIFICATION

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MAINE AGRICULTURAL EXPERIMENT STATION
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ABSTRACT

A soil microcosm experiment was conducted to (a) compare dilute H_2SO_4 , NH_4NO_3 fertilizer, and prilled S as possible experimental soil acidifying treatments, and (b) observe soil chemical response to simulated throughfall and acidifying treatments. Soil profiles were reconstructed in 91 cm tall acrylic microcosms using soil material collected from a single Tunbridge series pedon. Simulated throughfall (pH 4.6) was applied at twice the ambient rate, and all treatments were applied to the microcosms for a 6 month period.

Simulated throughfall had a significant effect on soil chemistry, resulting in increased exchangeable bases and pH in the mineral soil horizons but little effect on the O horizon. Of the acidification treatments only simulated acid rain (i.e. dilute H_2SO_4) had significant effects on soil chemistry when compared to the control and the dry (i.e. prilled S and NH_4NO_3) treatments. This reflected the relatively slow dissolution rate of the dry treatments coupled with the short duration of the experiment. Simulated acid rain decreased exchangeable base cations and pH while increasing exchangeable Al. The 2.5 cm layer of Bs horizon material immediately below the abrupt E horizon boundary proved to be the soil layer most responsive to chemical alteration.

INTRODUCTION

Acid deposition effects on soils and associated terrestrial and aquatic ecosystems continues to be the focus of scientific research and political debate. Many of the major processes involved in the chemical response of soils to elevated rates of S and N deposition have been identified but are still incompletely understood and difficult to predict. Much of our understanding was summarized by the U.S. Environmental Protection Agency (1983) critical assessment document on this issue, and Bockheim (1983) presents a literature review and tabulation of the results of simulated acid rain studies on soils. This area of research remains active with recent papers by Hern et al. (1985) and Rutherford et al. (1985) further refining our understanding for forest soil materials. In general, acid deposition has been shown to promote the leaching of base cations (e.g. Ca, Mg, K, Na), reduce pH, and increase labile Al in soils when effects are detectable either under experimental or field conditions. Numerous other physical and biological effects have also been suggested but are not well understood.

The difficulty in acid deposition research is that almost no "control" sites are available for field studies, and policy decisions simply cannot be postponed for decades or centuries for the sake of sound ecological studies of chronic stress on natural systems. One approach to this problem is to develop knowledge-based computer models that predict future ecological effects of different levels of acid deposition. Several such models (Schnoor et al. 1983, Gherini et al. 1985, Cosby et al. 1985) are currently utilized to guide policy decisions on the role of acid deposition in freshwater acidification. However, very little testing and refinement of these models has occurred over a wide range of ecosystem types. One approach to model refinement is to experimentally acidify a watershed ecosystem and compare the actual results with those predicted by the models.

While the experimental acidification of a watershed may be a logical approach, the practical aspects of carrying out such a study are significant. One question is whether to use wet treatments such as simulated throughfall or acid rain, or dry treatments such as elemental S or a nitrogen fertilizer (e.g. NH_4NO_3). Popovic (1980) found some success in the experimental acidification of Swedish forest soils using elemental S, and Maynard et al. (1983, 1986) have shown that soil acidification has resulted from particulate S deposition due to local sour gas processing in west-central Alberta. Therefore, this study was conducted to (a) compare alternative approaches to experimental soil acidification using soil microcosms, and (b) further refine our understanding of forest soil response to S and N deposition.

EXPERIMENTAL METHODS

Materials

A single pedon from the Tunbridge series was selected for sampling near Mud Pond in the Tunk Mountain area of Hancock County in eastern Maine. The soil is classified as a coarse-loamy, mixed, frigid Typic Haplorthod. The sampling pedon was under a relatively mature forest cover dominated by beech (*Fagus grandifolia* Ehrh.), red maple (*Acer rubrum* L.), and red spruce (*Picea rubens* Sarg.).

Samples of the O horizon were collected intact. Bulk samples of the E, Bs, and Bw horizons were collected and sieved through a 1.27 cm mesh screen in the field. All samples were air-dried in the greenhouse prior to soil profile reconstruction, and individual mineral horizon materials were thoroughly mixed by multiple passes through a riffle splitter to insure homogeneity of the bulk samples.

Twenty soil microcosms were assembled in acrylic columns made of 3.2 mm thick acrylic measuring 91 cm in length by 10.8 cm inner diameter. Identical soil profiles were reconstructed in each microcosm consisting of an O horizon (intact), E horizon, Bs horizon, and Bw horizon. Table 1 shows selected chemical properties of the soil horizon materials used to reconstruct soil profiles in the microcosms.

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Soil microcosms were housed in a constant temperature facility. Room temperature over the six month treatment period was adjusted monthly to match average monthly air temperatures during the growing season for eastern Maine. Monthly room temperatures were 16.2, 19.3, 18.7, 14.8, 9.7 and 4.1⁰C for months one through six, respectively.

Table 1 - Selected¹ chemical characteristics of reconstructed soil profiles¹.

Horizon	Depth	pH _w	pH _s	Effective C.E.C.	B.S.	O.M.
	- cm			- meq 100 g ⁻¹ -	----- % -----	
O	7-0	4.55	3.37	26.9	59	63.6
E	0-5	3.88	3.41	4.5	18	2.2
Bs	5-40	4.88	4.68	12.2	19	8.4
Bw	40-65	4.90	4.67	8.6	11	4.5

¹ Chemical analyses defined in Analysis section.

Treatments

All microcosms received the equivalent of 100 cm of simulated throughfall evenly divided into twice weekly applications over a six month treatment period. Simulated throughfall composition is described in Table 2. The 100 cm application approximates annual precipitation amounts for eastern Maine.

In addition to the simulated throughfall, the microcosms were subjected to eight different treatments as shown in Table 3. These materials were selected to examine possible alternative approaches to the experimental acidification of forest soils. Prilled S was in the form of "Popcorn" sulfur (courtesy of Union Oil Company, Los Angeles, California) which is a dry, reduced S material with a guaranteed 95.0% S analysis. Standard NH₄NO₃ (33.0% N) was used for the N treatments. An "irrigation effect" treatment was included to determine if the additional water added in the dilute H₂SO₄ treatments had a significant effect on leachate chemistry.

Table 2 - Ionic composition of simulated throughfall (pH = 4.6).

Base Cations	mg/l	Metals	mg/l	Anions	mg/l
Ca	0.81	Zn	0.03	SO ₄	2.44
Mg	0.23	Ni	0.01	NO ₃	3.14
K	2.02	Cu	0.05	Cl	2.32
NH ₄	0.45	Cd	0.01	F	0.03
Na	0.05	Pb	0.01		
		Mn	0.01		

Analysis

Following the six month treatment period, soils were collected from the microcosms and air-dried in the greenhouse. Soil samples were collected from each soil microcosm as bulk O horizon (O), bulk E horizon (E), the first 2.5 cm of the Bs horizon (Bs-1), the next 5 cm of the Bs horizon (Bs-2), the remainder of the Bs horizon as a bulk sample (Bs-3), the first 2.5 cm of the Bw horizon (Bw-1), and the remainder of the Bw horizon as a bulk sample (Bw-2). Subsamples of air-dried soil were oven-dried at 105⁰C (mineral horizons) or 60 C (organic horizons) to permit presentation of the results on an oven-dried basis. All analyses were conducted on the air-dried materials after sieving through a 2 mm mesh standard sieve.

Table 3 - Treatments used in the soil microcosm study for a six month treatment period in addition to the simulated throughfall.

Name	Symbol	Replications	Material	Rate
Control	C	2	-	-
Irrigation Effect	IR	2	H ₂ O	25 cm H ₂ O
Simulated Acid Rain (1)	AR1	3	H ₂ SO ₄	100 kg S/ha
Simulated Acid Rain (2)	AR2	3	H ₂ SO ₄	200 kg S/ha
Nitrogen (1)	N1	2	NH ₄ NO ₃	25 kg N/ha
Nitrogen (2)	N2	2	NH ₄ NO ₃	50 kg N/ha
Prilled Sulfur (1)	S1	3	"Popcorn" S	100 kg S/ha
Prilled Sulfur (2)	S2	3	"Popcorn" S	200 kg S/ha

Soil samples were analyzed for the following parameters according to the methods described in Cappo et al. (1986):

- (a) pH_w (in water),
- (b) pH_s (in 0.01 M CaCl₂),
- (c) exchangeable Ca, Mg, K, Na (by 1 N NH₄Cl),
- (d) exchangeable acidity and Al (by 1 N KCl),
- (e) soluble SO₄ (water extractable),
- (f) adsorbed SO₄ (0.01 M NaH₂PO₄ extractable),
- (g) total organic matter (by loss-on-ignition),
- (h) cation exchange capacity (by summation), and
- (i) base saturation (calculated).

Data were analyzed using SAS (1985) with mean separations carried out by the GLM procedure using Duncan's multiple range test.

RESULTS AND DISCUSSIONField Increment Data

Soils were sampled at 2 cm depth intervals from the field site to (a) provide a perspective on the vertical variability in soil chemical properties under undisturbed field conditions, and (b) provide data to compare the depth trends and possible differences in chemical effects of treatments in the experimental microcosms.

Table 4 shows that, as expected, the O horizon of this pedon had a high organic matter content and exchange acidity, as well as a relatively high reserve of exchangeable bases. Most of the B horizon was very low in exchangeable bases. The first 2 cm of the Bs horizon had the lowest pH and highest C.E.C. of all the Bs increments. This reflects the accumulation of organic materials at the very top of the Bs with a relatively large source of H from dissociation of organic functional groups as reported by other authors. The accumulation of organic materials at the top of the B horizon is typical of the podzolization process which leads, in some cases, to the development of Bh or Bhs horizons. It is interesting to note that SO_4 appears to accumulate in the upper Bs horizon reflecting the abundance of illuviated sesquioxide materials. However, the greatest amount of adsorbed SO_4 was found in the 13 to 15 cm Bs horizon increment. We interpret the lower adsorbed SO_4 in the first few Bs horizon increments to be the result of inhibition of SO_4 adsorption by the higher organic matter content in the upper Bs horizon. This is consistent with the results of Johnson and Todd (1983) who showed greater SO_4 adsorption with higher Fe and Al oxide contents in the soil, and that organic matter may inhibit this adsorption process.

Table 4 - Soil chemical characteristics by 2 cm depth increments from the pedon sample near Mud Pond, Maine for the soil microcosm acidification experiment.

HORIZON	DEPTH	O.M.	pH _w	pH _s	Ca	Mg	K	Na	E.A.	Al _{KCl}	C.E.C.	B.S.	SO ₄ -S _{soil}	SO ₄ -S _{ads}
	--cm--	--%			-meq 100 g ⁻¹							-%-	-----mg kg ⁻¹ -----	
Oe	7-5	86.58	4.46	3.51	11.35	3.46	1.28	0.15	59.32	0.54	75.55	21.49	-	-
Oa/Oe	5-3	39.44	4.61	3.69	2.26	0.84	0.50	0.08	85.39	6.41	89.07	4.14	-	-
Oa	3-0	29.86	4.16	3.30	6.58	1.54	0.82	0.21	90.71	3.73	99.87	9.18	-	-
E	0-2	5.23	3.66	3.17	0.40	0.19	0.04	0.04	48.18	2.81	48.85	1.37	-	-
E	2-5	6.88	3.82	3.15	0.50	0.22	0.08	0.06	49.17	3.01	50.04	1.73	-	-
Bs	5-7	17.48	4.91	4.25	0.18	0.10	0.14	0.04	33.29	3.16	33.76	1.39	12	119
Bs	7-9	16.74	5.10	4.68	0.02	0.06	0.09	0.03	14.10	0.88	14.31	1.41	9	165
Bs	9-11	13.65	5.02	4.78	0.08	0.05	0.06	0.03	11.17	0.78	11.40	2.01	8	166
Bs	11-13	12.36	5.15	4.84	<0.01	0.03	0.07	0.04	6.78	0.36	6.92	2.01	10	129
Bs	13-15	10.47	5.02	4.78	<0.01	0.03	0.07	0.03	15.06	0.23	15.18	0.80	8	233
Bs	15-17	7.91	4.94	4.80	<0.01	0.03	0.04	0.02	7.03	0.40	7.12	1.28	6	132
Bs	17-19	7.93	4.99	4.72	<0.01	0.02	0.06	0.03	5.49	0.52	5.60	1.91	6	116
Bs	19-21	7.25	4.91	4.71	<0.01	0.03	0.07	0.03	8.98	0.49	9.11	1.47	5	75
Bs	21-23	5.39	4.85	4.65	<0.01	0.01	0.03	0.02	5.45	0.65	5.52	1.28	4	60
Bs	23-25	6.02	4.60	4.65	<0.01	0.02	0.03	0.02	4.66	0.58	4.73	1.39	4	59
Bs	25-27	5.94	4.68	4.70	<0.01	0.01	0.03	0.03	6.22	0.64	6.29	1.11	4	71
Bs	27-29	5.52	4.70	4.74	<0.01	0.01	0.03	0.02	6.22	0.66	6.27	0.91	4	59
Bs	29-31	5.52	4.74	4.68	<0.01	0.01	0.03	0.02	8.57	0.85	8.63	0.70	4	36
Bs	31-33	5.34	4.79	4.58	<0.01	0.02	0.04	0.03	10.50	0.65	10.59	0.82	4	63
Bs	33-35	5.05	4.73	4.61	<0.01	0.01	0.02	0.02	12.80	0.84	12.86	0.46	4	43
Bs	35-38	4.75	4.73	4.68	<0.01	0.01	0.02	0.02	12.04	0.69	12.09	0.35	3	33
Bw	38-40	5.03	4.90	4.69	<0.01	0.01	0.03	0.02	10.51	0.71	10.57	0.59	4	51
Bw	40-42	4.82	4.83	4.59	<0.01	0.01	0.04	0.02	12.04	0.94	12.12	0.58	3	24
Bw	42-44	4.91	4.98	4.59	<0.01	0.01	0.04	0.02	11.67	0.78	11.74	0.60	5	37
Bw	44-46	4.31	4.84	4.68	<0.01	0.02	0.05	0.03	10.10	0.76	10.20	0.92	4	29
Bw	46-48	4.05	4.79	4.75	<0.01	0.01	0.03	0.02	6.21	0.59	6.27	1.02	3	8
Bw	48-50	2.57	5.05	4.85	<0.01	0.01	0.03	0.02	6.19	0.56	6.24	0.90	4	13
Bw	50-52	2.49	4.83	4.79	<0.01	<0.01	0.02	0.01	7.34	0.59	7.38	0.48	2	3
Bw	52-54	2.48	4.63	4.74	<0.01	<0.01	0.02	0.02	4.25	0.33	4.28	0.78	2	4
Bw	54-56	2.75	4.90	4.71	<0.01	<0.01	0.02	0.02	3.09	0.45	3.13	1.20	2	4
Bw	56-58	2.59	4.74	4.68	<0.01	<0.01	0.30	0.02	4.25	0.49	4.56	6.96	3	7

Pooled Microcosm Data

Table 5 shows the chemical characteristics of soils collected from the microcosms following six months of treatment with simulated throughfall with the data pooled across all twenty microcosms. Clearly these soils were chemically altered by the simulated throughfall which we attribute to (a) probable differences between the simulated throughfall and throughfall composition from the field site, (b) the application rate being twice that of field conditions (i.e. one year's volume applied within the six month period), and the lack of transpiration by higher plants. Overall, simulated throughfall tended to increase the exchangeable bases in mineral soil horizons but had little effect on the O horizon when compared to the chemistry of the field increment samples in Table 4. Soil pH was slightly higher in the B horizons of the microcosms as compared to the field increment samples which reflects the higher levels of exchangeable bases.

It is interesting to note that Table 5 shows a trend for the upper 2.5 cm of the Bs horizon (i.e. Bs-1) to have lower exchangeable base cations and a significantly lower pH than soil below this initial Bs increment. Keeping in mind that all of the Bs material was homogenized prior to profile reconstruction, it appears that the increment of the B horizon immediately below the abrupt transition from the E horizon better reflected the effects of acid leaching than bulk B horizon samples. Similarly, the Bs-1 layer had significantly more adsorbed and soluble SO_4 than the Bs-2 or Bs-3. Kelly et al. (1984) also reported differences in chemical response for the top 3.5 cm of soil exposed to simulated acid rain in microcosms when compared to deeper soil layers. These results suggest that the most marked effect of acid leaching on soils may be evident within very thin soil layers immediately beneath distinct morphological boundaries between horizons.

Therefore the effect of the simulated throughfall itself was to accelerate base cation leaching, mobilize Al, and reduce soil pH under these experimental conditions.

Table 5 - Chemical characteristics of soils based on pooled data from all soil microcosms following six months of treatment (h=20).¹

HORIZON	DEPTH	O.M.	pH _w	pH _s	Ca	Mg	K	Na	Al _{KCl}	E.A.	C.E.C.	B.S.	SO ₄ -S _{SO1}	SO ₄ -S _{ads}
	--cm--	---							-----meq 100 g ⁻¹ -----			---	-----mg kg ⁻¹ -----	
O	7-0	63a	4.55c	3.37d	13.3a	3.12a	0.92a	0.08a	1.12b	59.7a	77.13a	25.8a	17a	13de
E	0-5	2c	4.34d	3.55c	0.27b	0.07b	0.05b	0.02b	1.97a	26.6b	26.99b	1.5b	2d	(-5de)
Bs-1	5-7.5	9b	4.59c	4.52b	0.01b	0.01b	0.06b	0.02b	0.96b	13.1c	13.24c	0.8b	10b	180a
Bs-2	7.5-12.5	9b	4.79b	4.69a	0.04b	0.01b	0.07b	0.02b	0.62c	10.3c	10.49c	1.5b	7c	144b
Bs-3	12.5-40	9b	5.27a	4.78a	0.11b	0.03b	0.08b	0.02b	0.44c	8.1c	8.33c	3.1b	6c	101c
Bw-1	40-42.5	5bc	5.31a	4.77a	0.02b	0.02b	0.05b	0.02b	0.47c	8.1c	8.22c	1.6b	6c	32d
Bw-2	42.5-65	5bc	5.27a	4.76a	0.07b	0.07b	0.06b	0.02b	0.49c	9.3c	9.77c	4.1b	5cd	33d

¹ Means followed by the same letter are not significantly different within columns at the 0.05 level of confidence using Duncan's multiple range test.

If it is the upper few cm of the B horizon where the effect of acid leaching is best detected, then long-term soil monitoring studies and surveys aimed at determining acid deposition effects may need to modify soil sampling protocols to isolate this fairly thin soil layer. It does not seem reasonable to expect bulk soil samples to reveal subtle trends in chemistry over time, or along depositional gradients, if only a very thin layer of soil is highly responsive to acidification effects. From our knowledge of soil genesis and the gradual development of soil morphologies over time, it seems reasonable to expect that thin layers of soil at abrupt morphological boundaries would best reflect relatively recent changes in the chemistry of solutions leaching through the profile, particularly in the case of podzolic forest soils of the Northeast. However, results from this experiment are short-term responses to relatively intense treatments that may cause soil response to be different from responses to chronic acid leaching over decades in the field, and extrapolation to the field environment is difficult.

The effects on soil chemistry shown here are consistent with changes in leachate chemistry from the microcosms reported by Fernandez and Kosian (1986). They showed that leachate chemistry from these microcosms exhibited an overall 0.5 pH unit decline and increased concentrations of base cations, Fe, and Al over the six month period.

Treatment Effects

Both of the dry acidifying materials (i.e. prilled S and $(\text{NH}_4)_2\text{SO}_4$) had minimal effects on soil or leachate chemistry based on the soil data reported here and leachate chemistry reported by Fernandez and Kosian (1986). The lack of effect was believed to be due to the short duration of the experiment and possibly the cool temperatures in the microcosm chamber that may have inhibited microbial oxidation of elemental S.

Tables 6 through 9 show the data for pH, B.S., exchangeable Al, and soluble SO_4 data, respectively from the microcosm soils collected following the treatment period. Only the AR2, S2, and N2 (Table 3) treatments are shown to simplify this discussion since lower rates of

Table 6 - Soil pH (in water) from the microcosm experiment for selected treatments.¹

HORIZON	CONTROL	AR2	S2	N2
O	4.41 cA	4.13 cA	4.60 bA	4.55 aA
E	4.20 cBC	4.07 cC	4.45 bAB	4.40 aAB
Bs-1	4.56 cA	4.71 bA	4.54 bA	4.49 aA
Bs-2	4.64 bcB	5.04 abA	5.05 aAB	4.64 aB
Bs-3	5.08 abA	5.34 aA	5.41 aA	5.05 aA
Bw-1	5.13 abA	5.26 aA	5.22 aA	4.99 aA
Bw-2	5.31 aA	5.22 aA	5.37 aA	5.07 aA

¹ Means followed by the same letters are not significantly different at the 0.05 level. Lower case letters compare means within columns, upper case letters compare means within rows.

amendments (i.e. AR1, S1, and N1) showed the same effects but to a lesser extent. Similarly individual base cations and adsorbed SO₄ show trends consistent with B.S. and soluble SO₄, respectively.

These results indicate that the simulated acid rain treatments (i.e. AR2) had a marked effect on soil chemistry due to the highly labile form of both H and SO₄ in this treatment compared to the others that were used. The net effect of the AR2 treatment was to (a) lower soil pH and exchangeable base cations, and (b) increase the exchangeable Al and soluble SO₄. It is interesting to note again that the Bs-1 layer exhibited greater chemical responses much more than the remainder of the Bs horizon, and in the case of the Bs-1 layer in the AR2 treatment, exchangeable Al and soluble SO₄ were significantly greater than both the other treatments or underlying Bs layers. Soluble SO₄ in the AR2 treatment Bs-1 layer was twice the soluble SO₄ concentration in the Bs-2 layer, and ten times the concentration in the E horizon. Very little evidence, if any, of the prilled S was found in the soluble SO₄ data for

Table 7 - Soil base saturation from the microcosm experiment for selected treatments.¹

HORIZON	CONTROL	AR2	S2	N2
	----- % -----			
O	16.02 aA	14.48 aA	26.59 aA	25.56 aA
E	1.26 aBC	0.88 bC	1.76 bcAB	1.43 bABC
Bs-1	0.96 aAB	0.82 bABC	0.60 cBC	0.74 bC
Bs-2	0.82 aA	2.54 bA	3.53 bA	0.74 bA
Bs-3	2.73 aA	2.53 bA	2.73 bcA	2.13 bA
Bw-1	2.61 aAB	1.26 bAB	1.64 bcAB	0.93 bB
Bw-2	2.18 aA	1.63 bA	1.34 bcA	0.91 bA

¹ Means followed by the same letters are not significantly different at the 0.05 level. Lower case letters compare means within columns, upper case letters compare means within rows.

the S2 O horizon. It should be noted that any visible particles of prilled S in the O horizon were removed during destructive sampling of the microcosms following the treatment period. Janzen and Bettany (1986) reported that powdered elemental S had not completely converted to SO₄ after 124 days in a growth chamber. Apparently the prilled S is significantly more insoluble than even the powdered S forms.

The N2 treatment showed little effect on soil chemistry even though NH₄NO₃ should have been fairly soluble. Due to the low replications in this study imposed by practical constraints, it was difficult to statistically confirm numerical trends, particularly for the NH₄NO₃ treatments which produced the greatest variation among replicates. There was a trend, however, for the depletion of base cations in most soil layers below the Bs-1 for the N2 treatment. Huete and McCall (1984) reported evidence for a greater efficiency in base cation leaching with

higher NO₃/SO₄ ratios in precipitation. These data may also reflect that phenomenon suggesting the efficiency of NO₃ versus SO₄ in leaching processes should be studied further.

Table 8 Soil exchangeable aluminum from the microcosm experiment for selected treatments.¹

HORIZON	CONTROL	AR2	S2	N2
	----- meq 100 g ⁻¹ -----			
O	1.63 aA	1.35 abA	0.86 bA	0.43 bA
E	1.97 aA	2.10 aA	1.89 aA	1.97 aA
Bs-1	0.73 bB	1.32 abA	0.88 bB	0.82 bB
Bs-2	0.55 bAB	0.64 cbAB	0.49 bB	0.68 bAB
Bs-3	0.48 bA	0.32 cA	0.48 bA	0.53 bA
Bw-1	0.52 bA	0.35 cA	0.56 bA	0.53 bA
Bw-2	0.47 bA	0.38 cA	0.59 bA	0.52 bA

¹ Means followed by the same letters are not significantly different at the 0.05 level. Lower case letters compare means within columns, upper case letters compare means within rows.

Table 9 - Soil soluble sulfate¹ from the microcosm experiment for selected treatments.

HORIZON	CONTROL	AR2	S2	N2
	----- mg kg ⁻¹ -----			
O	42 aB	83 aA	46 aB	34 aB
E	4 cBC	9 dA	3 dC	4 bBC
Bs-1	14 bcB	92 aA	12 cdB	14 bB
Bs-2	11 bcA	40 bA	17 bcA	10 bA
Bs-3	18 bcAB	22 cA	19 bcAB	5 bB
Bw-1	19 bAB	15 cdAB	23 bA	11 bB
Bw-2	13 bcA	16 cdA	12 cdA	10 bA

¹ Means followed by the same letters are not significantly different at the 0.05 level. Lower case letters compare means within columns, upper case letters compare means within rows.

CONCLUSIONS

Simulated acid rain as dilute H₂SO₄ was clearly shown to be the best approach to short-term experimental acidification of soils. Whether other treatments may prove useful over longer time periods and under field conditions requires further study. One of the inherent problems with any of the dry amendments is that the investigator has relatively little control over the rate of release of strong acid anions into the soil system.

As expected, leaching of these microcosms with acidic solutions resulted in increases in exchangeable Al and decreases in exchangeable base cations along with soil pH. Sulfate increased throughout the soil horizons as a result of adsorption from the simulated throughfall, and dramatically increased in the simulated acid rain treatments. A noteworthy result was that only a very thin layer of the B horizon immediately below the abrupt

boundary with the E horizon showed the greatest response to treatments. This suggests that in northeast Spodosols with abrupt horizon transitions in the solum, very specific portions of the soil profile may need to be studied to determine possible chronic effects of acid deposition on soil chemical status.

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