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1974/75 PROGRESS REPORT
[FINAL]

NITROGEN RETENTION IN COOL DESERT SOILS

J. J. Skujins
Utah State University

US/IBP DESERT BIOME
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Ecology Center, Utah State University, Logan, Utah 84322

ABSTRACT

An area (1.1 ha) in southern Curlew Valley was cultivated, seeded with crested wheatgrass and treated with organic amendments and nitrification inhibitors. It is expected that some surface, blue-green algae-lichen-fixed nitrogen may be accumulated in the soil organic matter. Since the treatments and evaluation of soil processes and plant yields will require a number of years, the data obtained during the first two years on soil chemistry and biological activities are considered only as baseline values. The project is expected to be continued beyond the time of IBP support.

INTRODUCTION

Studies on several processes of nitrogen transformation in Curlew Valley soils have shown that there is extensive and considerable nitrogen fixation by surface (photosynthetic) microorganisms (blue-green algae), which also act as primary producers. Most of the fixed nitrogen is released as NH_4^+, nitrified and denitrified in the presence of easily available organic substrate. The process is enhanced by the spring and fall rainy periods. Some of the nitrogen may also be lost due to volatilization of NH_3. The concentration of organic matter in these soils is low and the C:N ratios are low (8-12), indicating an excess of nitrogen, or conversely, that all of the available organic carbon has been used for the immobilization of nitrogen. The reverse process, mineralization of nitrogen, starts at a C:N ratio of about 20-30 in agricultural soils. By inhibiting nitrification, nitrogen loss would be minimized and, with a concurrent addition of organic matter, the excess nitrogen may be immobilized and stabilized.

OBJECTIVES

The objectives of this project are to determine:

1. The effects of the application of inhibitors of nitrification and of several carbohydrate-containing industrial residue materials (sawdust, shredded paper and plowed-under sagebrush) on the facility of a desert soil to retain naturally fixed nitrogen upon inhibition of nitrification.
2. The feasibility of the treatment of the first objective for concurrent seeding of treated areas with *Agropyron cristatum* and the effect on its yield.

METHODS

Analytical methods and procedures for laboratory and field work in this project are the same as used for the project entitled "Nitrogen dynamics in stands dominated by some major cool desert shrubs" (Skujins and West 1974), where methods for determination of nitrification potential (DSCODE A3USQ06), dehydrogenase activity (A3UBJJ4), respiration (A3UBJJ1), proteolysis (A3USQ02) and pH (A3UBJJ6) have been described. Chemical analysis of soils (A3USQ01) was performed by the Soils Science Laboratory at Utah State University.

Table 1 shows the nitrogen retention treatment scheme. The experimental site in south Curlew Valley, Utah, was dominated largely by sagebrush (*Artemisia tridentata*) with a few annuals interspersed among the sagebrush. Most of the area chosen was covered by a blue-green algal lichen crust.

Prior to treatment, four adjacent 20 x 140 m strips were divided into thirty-three 20 x 20 m plots, with each plot being 0.04 ha, as shown in Table 1.

Soil samples were collected prior to any treatments on April 2, 1974, as shown in Table 2, with the depth of sampling for each plot indicated as below:

1 = 0-3 cm
2 = 5-20 cm
3 = 40-50 cm
4 = 70-80 cm

Due to resource limitations, not all plots were sampled and some plots were combined for initial and subsequent sampling as indicated in Tables 2-14.

According to the treatment scheme in Table 1, 2-chloro-6 (trichloromethyl) pyridine (N-Serve; Dow Chemical Co.) was sprayed uniformly over the surface of the designated plots on May 28, 1974.

A Hudson Utility sprayer (Hudson Mfg. Co., Chicago, Ill.) containing 93.3 ml of N-Serve (formulation M-3906; 240 g N-Serve/liter) diluted to 2 liters with distilled water was used. The pressure pump provided enough pressure so that a steady walking pace enabled uniform spraying of the diluted N-Serve over a 20 x 20 m plot. The above procedure was repeated for each of the plots sprayed, with an application rate of 560 g of N-Serve/ha.

For strip 1, all sagebrush plants were cut by chain saw and removed from the site. On strip 2 (May 30, 1974) the sagebrush was plowed under using a notched disc plow. The depth of discing was approximately 10 cm. On strip 3, 840 kg of air-dry, shredded newspaper were spread uniformly and plowed under with the sagebrush (May 30, 1974). The newspaper shreds were approximately 1-5 cm in size. Strip 4 was spread with 840 kg of air-dry, Douglas-fir sawdust on May 18, 1974, and plowed under with the sagebrush cover on May 30, 1974.

Soil samples were again obtained from each plot on August 8, 1974. On October 18 and 19, 1974, a second spraying of N-Serve was performed, but at a rate of 840 g of N-Serve/ha.

The designated plots (Table 1) were seeded by a disc plow on November 12, 1974; Fairway crested wheatgrass (Seed I)

Table 1. Treatment scheme and 20 x 20 m plot (sampling) locations

Treatment	Sagebrush Removed	Vegetation (Sagebrush) Plowed Under	Vegetation and Shredded Paper Plowed Under	Vegetation and Sawdust Plowed Under
N-Serve	1	2	3	4
Seeded I (Fall 1974)	5	6	7	8
Seeded II (Fall 1974)	9	10	11	12
N-Serve Seeded I (Fall 1974)	13	14	15	16
N-Serve Seeded II (Fall 1974)	17	18	19	20
N-Serve Seeded I (Fall 1974)	21	22	23	24
N-Serve Seeded II (Fall 1974)	25	26	27	28
No Treatment	29	30	31	32
No Treatment	33 Vegetation (sagebrush) left intact			

and Siberian crested wheatgrass (Seed II) were seeded at a rate of 14.0 and 11.3 kg seed/ha, respectively. The depth of discing was approximately 0.3-0.5 cm.

Nitrification potential was determined according to the methods described in the 1972 progress report (Skujins and West 1973; A3USQ06). Samples 4-1, 4-2, 3-1, 3-2, 1-1, 1-2, (14 and 15) -1, (14 and 15) -2 and (7 and 8) -4 were perfused for 21 days with the last sampling day being day 21. Sampling days 18 and 20 were for 16-1, 16-2, (19-20) -1, (19 and 20) -2, (19 and 20) -3, (19 and 20) -4, (17 and 18) -1, (17 and 18) -2 and (17 and 18) -3.

The samples taken on April 4 were analyzed for fixed NH_4^+ and exchangeable NH_4^+, according to Skujins and West (1973), before and after perfusion. August 8 samples were analyzed for fixed NH_4^+, total N, exchangeable NH_4^+ and NO_2^- and NO_3^-, also according to Skujins and West (1973; A3USQ01).

During 1975, the test plot in south Curlew Valley was sprayed with N-Serve (840 g N-Serve/ha) once each month during April, June and October (the vegetative seasons). Soil samples were again obtained for nitrification analysis on July 2, 1975.

Laboratory experiments modeling conditions similar to the field experiment were also initiated. Three surface soil samples (0-3 cm deep), each from an area in Curlew Valley dominated by *Artemisia tridentata*, *Ceratoides lanata* or *Atriplex confertifolia*, were treated as follows:

Treatment 1. 100 g soil in a 1-liter flask, moistened with distilled water to —1 to —2 bars and air-dried for 3 weeks.

Treatment 2. 100 g soil plus 3.0 mg $(^{15}NH_4)_2SO_4$ (30 A % excess) in a 1-liter flask, moistened with distilled water to —1 to —2 bars and air-dried for 3 weeks.

Treatment 3. 100 g soil plus 3.0 mg $(^{15}NH_4)_2SO_4$ (30 A % excess) plus N-Serve (7 μg/g soil) in a 1-liter flask, moistened with distilled water to —1 to —2 bars and air-dried for 3 weeks.

All three treatment systems were incubated in the dark at room temperature. Volatilized ammonia was recovered in a gas-washing bottle containing a 1% H_2SO_4 solution. After the 3-week incubation period, the soil was analyzed for NO_2^-— and NO_3^-—N, exchangeable and fixed NH_4^+—N, and organic nitrogen.

RESULTS

The project was initiated in 1974. Any data obtained on soil chemistry and biological activities should be considered as baseline values.

Initial (baseline) carbon, nitrogen and nitrate content are shown in Table 2, ammonium analysis in Table 3, pH in Table 4, respiration in Table 5, dehydrogenase in Table 6 and proteolytic activity in Table 7. The pretreatment nitrification potential data are given in Tables 8 to 19. The ammonium, organic nitrogen and nitrate/nitrite contents for samples collected on August 8, 1974, are shown in Table 20. The soil pH values for the same collection date are shown in Table 21 and nitrification potentials in Tables 22 to 24.

Laboratory data concerning the influence of applied N-Serve on ammonia volatilization are shown in Table 25. The levels of NO_2^-—N and NO_3^-—N are also given. As indicated, the amount of volatilized NH_3 from the N-Serve-treated soil decreased from week to week, but differed from the other two experimental systems as the level of volatilized NH_3 remained relatively constant during the second and third weeks. However, the control soils and the ^{15}N ammonium sulfate treated soils experienced fluctuations during the same experimental time period.

Table 2. Soil chemical analysis; pretreatment, April 4, 1974

Plot	% Organic C	% Total N	μg/g NO_3^-
4-1	1.8	.22	3.5
4-2	1.6	.16	8.3
3-1	2.4	.25	25.5
3-2	1.3	.15	12.4
1-1	2.2	.24	32.3
1-2	1.6	.18	8.5
(5 and 6)-1	2.0	.23	4.0
(5 and 6)-2	1.4	.15	6.2
(5 and 6)-3	1.0	.12	5.3
(5 and 6)-4	.4	.06	2.8
13-1	1.9	.24	.7
13-2	1.6	.21	4.7
(7 and 8)-1	1.9	.26	16.0
(7 and 8)-2	1.1	.15	8.8
(7 and 8)-3	.9	.11	8.9
(7 and 8)-4	.4	.05	3.6
(14 and 15)-1	1.6	.20	8.7
(14 and 15)-2	1.3	.19	23.0
16-1	1.8	.21	2.0
16-2	1.8	.16	6.2
(19 and 20)-1	2.2	.23	1.8
(19 and 20)-2	1.4	.16	7.7
(19 and 20)-3	.8	.11	7.7
(19 and 20)-4	.5	.06	3.8
(21 and 22)-1	.8	.36	1.6

Table 26 gives the pH values of the samples collected on July 2, 1975, while Table 27 indicates the levels of NH_4^+—N, and NO_2^-— and NO_3^-—N in the N-Serve field-treated samples after perfusion. From the data in Table 27, it is observed that only four samples (plot 3; plots 7-8, control; plot 16; plots 21-22) have less than 2000 μg NH_4^+—N at the end of the 3-week incubation period. This is significant as each soil was amended with 2 mg $(NH_4)_2SO_4$ per gram of soil, thus suggesting that the sprayed N-Serve was still present in these soils. Furthermore, the levels of NO_2^-— and NO_3^-—N in the treated soils are, in general, less than the corresponding values in the control soils.

Table 28 shows the total N values of the samples retrieved on August 8, 1974, and July 2, 1975.

Table 3. Soil ammonium analysis; pretreatment, April 4, 1974 (μg NH_4^+—N/g)

Plot Sample	Fixed	Exchangeable
4-1	79.3	0.7
4-2	65.9	1.4
3-1	96.3	0.9
3-2	65.8	0.2
1-1	134.1	0.9
(5 and 6)-1	127.1	3.3
(5 and 6)-2	7.4	3.3
(5 and 6)-3	9.0	7.7
13-1	123.0	3.0
13-2	5.3	2.2
(7 and 8)-1	8.1	3.9
(7 and 8)-2	4.4	2.8
(7 and 8)-3	2.0	5.6
(7 and 8)-4	0.8	0
(14 and 15)-1	127.0	0.7
(14 and 15)-2	88.0	0
16-1	97.0	2.5
16-2	78.0	1.3
(19 and 20)-1	161	2.0
(19 and 20)-2	88	0
(19 and 20)-3	50	0
(19 and 20)-4	21.5	1.4
(17 and 18)-1	128.2	1.5
(17 and 18)-2	78	1.1
(17 and 18)-3	40	1.1
(17 and 18)-4	13	0.1
(21 and 22)-1	206	1.8
(21 and 22)-2	96.3	0.2
23-1	133.8	1.6
23-2	107.2	0.4
24-1	201	0.7
24-2	108.6	0.3

Table 4. Soil pH values; pretreatment, April 4, 1974

Plot	pH	Plot	pH
4-1	8.5	(14 and 15)-2	8.9
4-2	8.5	16-1	8.5
3-1	8.4	16-2	8.8
3-2	8.7	(19 and 20)-1	8.7
1-1	8.8	(19 and 20)-2	8.6
1-2	8.7	(19 and 20)-3	9.3
(5 and 6)-1	8.4	(19 and 20)-4	8.8
(5 and 6)-2	8.5	(17 and 18)-1	8.7
(5 and 6)-3	8.8	(17 and 18)-2	9.0
(5 and 6)-4	8.9	(17 and 18)-3	8.8
13-1	8.3	(17 and 18)-4	8.8
13-2	8.4	(21 and 22)-1	8.6
(7 and 8)-1	8.3	(21 and 22)-2	8.8
(7 and 8)-2	8.6	23-1	8.9
(7 and 8)-3	8.9	23-2	8.9
(7 and 8)-4	8.9	24-1	8.7
(14 and 15)-1	8.6	24-2	8.9

Table 5. Respiration; pretreatment, April 4, 1974*

Plot Sample	μm CO_2 evolved/g/min	Plot Sample	μm CO_2 evolved/g/min
4-1	62.3	(14 and 15)-2	51.2
4-2	82.3	16-1	55.3
3-1	67.8	16-2	53.0
3-2	62.9	(19 and 20)-1	28.4
1-1	72.8	(19 and 20)-2	35.6
1-2	55.2	(19 and 20)-3	49.3
(5 and 6)-1	82.4	(19 and 20)-4	27.6
(5 and 6)-2	43.7	(17 and 18)-1	60.2
(5 and 6)-3	52.7	(17 and 18)-2	61.0
(5 and 6)-4	25.3	(17 and 18)-3	44.3
13-1	75.3	(17 and 18)-4	36.0
13-2	35.5	(21 and 22)-1	37.0
(7 and 8)-1	48.0	(21 and 22)-2	25.6
(7 and 8)-2	49.4	23-1	46.8
(7 and 8)-3	23.4	23-2	33.4
(7 and 8)-4	35.7	24-1	63.0
(14 and 15)-1	37.3	24-2	46.6

*Respiration was measured at field moisture conditions, but computed on an oven-dry basis.

Table 6. Dehydrogenase activity; pretreatment, April 4, 1974

Plot Sample	mg formazan formed/g	Plot Sample	mg formazan formed/g
4-1	1.18	(14 and 15)-2	.42
4-2	.28	16-1	1.11
3-1	1.23	16-2	.25
3-2	.21	(19 and 20)-1	1.89
1-1	1.59	(19 and 20)-2	.18
1-2	.58	(19 and 20)-3	.05
(5 and 6)-1	.96	(19 and 20)-4	.04
(5 and 6)-2	.15	(17 and 18)-1	1.12
(5 and 6)-3	.02	(17 and 18)-2	.29
(5 and 6)-4	.01	(17 and 18)-3	.04
13-1	1.35	(17 and 18)-4	.03
13-2	.24	(21 and 22)-1	.24
(7 and 8)-1	1.77	(21 and 22)-2	.09
(7 and 8)-2	.04	23-1	1.43
(7 and 8)-3	.02	23-2	.30
(7 and 8)-4	.04	24-1	1.27
(14 and 15)-1	1.60	24-2	.41

Table 7. Proteolysis; pretreatment, April 4, 1974

Plot Sample	% Hydrolysis	Plot Sample	% Hydrolysis
4-1	40.0	(14 and 15)-2	17.0
4-2	16.0	16-1	30.0
3-1	43.0	16-2	15.0
3-2	14.0	(19 and 20)-1	39.0
1-1	47.0	(19 and 20)-2	4.2
1-2	20.0	(19 and 20)-3	5.2
(5 and 6)-1	25.0	(19 and 20)-4	3.6
(5 and 6)-2	2.5	(17 and 18)-1	38.8
(5 and 6)-3	4.2	(17 and 18)-2	13.5
(5 and 6)-4	0	(17 and 18)-3	4.6
13-1	43.5	(17 and 18)-4	4.0
13-2	14.0	(21 and 22)-1	40.5
(7 and 8)-1	39.0	(21 and 22)-2	17.0
(7 and 8)-2	5.0	23-1	49.0
(7 and 8)-3	1.8	23-2	18.0
(7 and 8)-4	4.0	24-1	42.4
(14 and 15)-1	41.0	24-2	18.0

Table 8. Nitrification potential; pretreatment, April 4, 1974, samples (Plot 1)

	μg NO_2^--N/g		μg NO_3^--N/g	
Days	0-3 cm	5-20 cm	0-3 cm	5-20 cm
*				
2	8.7	1.8	0	1.3
4	10.1	3.2	0	14.2
6	8.3	2.5	0	12.5
8	6.6	0.9	0	10.8
10	6.7	0.3	0	22.5
12	11.7	0	0	25.8
14	11.7	0	0	30.8
16	-	-	-	-
18	31.7	11.7	26.7	62.5
21	49.2	35.0	73.3	73.3

* Initial NH_4^+-N added = 2333 μg/g.

Table 9. Nitrification potential; pretreatment, April 4, 1974, samples (Plot 3)

	μg NO_2^--N/g		μg NO_3^--N/g	
Days	0-3 cm	5-20 cm	0-3 cm	5-20 cm
*				
2	10.2	.3	9.2	0
4	13.0	.8	19.2	1.3
6	11.2	1.0	39.2	1.3
8	6.6	1.2	46.7	11.7
10	5.8	1.3	62.5	2.5
12	8.9	2.5	46.7	13.3
14	20.0	5.2	135	20.8
16	-	-	-	-
18	279	60.0	229	34.2
21	695	236	333	41.7

* Initial NH_4^+-N added = 2333 μg/g.

Table 10. Nitrification potential; pretreatment, April 4, 1974, samples (Plot 4)

	μg NO_2^--N/g		μg NO_3^--N/g	
Days	0-3 cm	5-20 cm	0-3 cm	5-20 cm
*				
2	9.1	.8	0	0
4	13.3	2.2	2.5	3.9
6	7.9	3.2	5.0	9.2
8	15.5	4.9	13.3	7.5
10	15.1	12.4	0	40.0
12	31.0	57.6	0	25.8
14	82.9	203	0	46.7
16	-	-	-	-
18	398	1083	0	54.2
21	1208	1392	15.8	72.5

* Initial NH_4^+-N added = 2333 μg/g.

Table 11. Nitrification potential; pretreatment, April 4, 1974, samples

	μg NO_2^--N/g			μg NO_3^--N/g		
Days	0-3 cm	5-20 cm	30-50 cm	0-3 cm	5-20 cm	30-50 cm
*						
2	-	-	-	-	-	-
4	1.1	0.8	0.2	0	0	0
6	3.0	1.1	0.3	0	3.7	0
8	-	-	-	-	-	-
10	3.8	0.7	0.4	3.6	6.0	0
12	2.5	0.7	2.4	0	3.5	31.7
14	3.8	1.4	0.2	0	3.4	0
16	3.8	1.7	0.4	16.7	7.5	0
18	5.0	10.8	0.4	32.4	20.0	1.1
21	3.9	29.2	0.6	20.8	23.3	1.1

* Initial NH_4^+-N added = 2333 μg/g.

Table 12. Nitrification potential; pretreatment, April 4, 1974, samples (Plot 7)

	μg NO_2^--N/g		μg NO_3^--N/g	
Days	0-3 cm	5-20 cm	0-3 cm	5-20 cm
*				
2	4.2	-	0	-
4	-	2.4	-	3.8
6	4.0	3.3	24.2	13.3
8	3.2	-	32.5	-
10	2.5	6.2	27.5	1.2
12	2.3	87	31.7	12.5
14	3.7	97	42.5	16.7
16	4.8	466	41.7	26.7
18	6.1	580	50.8	20.0
20	7.2	667	50.0	20.0

* Initial NH_4^+-N added = 2333 μg/g.

Table 13. Nitrification potential; pretreatment, April 4, 1974, samples (Plot 8)

	μg NO_2^--N/g		μg NO_3^--N/g	
Days	0-3 cm	5-20 cm	0-3 cm	5-20 cm
*				
2	13.3	2.5	5.2	1.3
4	21.0	3.7	29.2	7.5
6	23.9	4.3	28.3	10.0
8	17.8	5.2	23.3	12.5
10	20.2	5.8	25.8	18.3
12	10.1	8.2	26.7	23.3
14	15.0	10.4	36.7	39.2
16	-	-	-	-
18	18.3	21.7	57.5	57.5
21	45.8	70.8	26.7	-

* Initial NH_4^+-N added = 2333 μg/g.

Table 14. Nitrification potential; pretreatment, April 4, 1974, samples (Plot 12)

	μg NO_2^--N/g		μg NO_3^--N/g	
Days	0-3 cm	5-20 cm	0-3 cm	5-20 cm
*				
2	10.0	.2	9.2	1.3
4	-	-	-	-
6	22.5	.7	15.8	5.2
8	36.7	.7	16.7	9.2
10	59.2	1.0	18.3	3.9
12	142	2.1	31.7	5.2
14	340	3.1	51.7	6.5
16	731	8.3	62.5	11.7
21	1258	114	56.7	25.0
23	1225	293	57.5	20.8

* Initial NH_4^+-N added = 2333 μg/g.

Table 15. Nitrification potential; pretreatment, April 4, 1974, samples (Plots 17 and 18)

	μg NO_2^--N/g				μg NO_3^--N/g			
Days	0-3 cm	5-20 cm	30-50 cm	70-80 cm	0-3 cm	5-20 cm	30-50 cm	70-80 cm
*								
2	0	1.5	0	0	0	10.0	0	0
4	-	-	-	-	-	-	-	-
6	8.3	3.1	.2	0	0	20.8	0	1.3
8	7.5	3.5	.1	0	5.0	5.0	9.2	1.3
10	7.2	4.0	.2	0	15.8	10.0	0	0
12	7.2	6.5	.4	0	15.8	25.0	0	0
14	15.0	13.3	.5	0	20.8	10.0	0	0
16	250	30.8	.4	0	20.8	25.8	5.0	0
21	230	280	.6	-	0	44.2	0	0
23	466	288	3.9	.42	25.8	41.7	0	0

* Initial NH_4^+-N added = 2333 μg/g.

Table 16. Nitrification potential; pretreatment, April 4, 1974, samples (Plots 19 and 20)

	$\mu g\ NO_2^-$-N/g				$\mu g\ NO_3^-$-N/g			
Days	0-3 cm	5-20 cm	30-50 cm	70-80 cm	0-3 cm	5-20 cm	30-50 cm	70-80 cm
*								
2	10.8	.9	.5	0	10.0	3.9	0	0
4	-	-	-	-	-	-	-	-
6	12.5	1.9	1.4	.2	10.0	0	0	0
8	10.0	2.0	1.6	.2	5.8	14.2	0	0
10	7.5	2.1	1.7	.2	5.0	5.0	9.2	0
12	10.0	4.3	2.9	.7	15.8	18.3	9.2	0
14	32.5	10.0	4.3	1.1	10.8	15.8	9.2	0
16	32.5	22.5	7.1	2.6	42	25.8	0	0
21	233	230	114	7.8	115	51.7	2.5	0
23	417	564	23.3	124	120	65	0	0

* Initial NH_4^+-N added = 2333 μg/g.

Table 17. Nitrification potential; pretreatment, April 4, 1974, samples (Plot 21)

	$\mu g\ NO_2^-$-N/g		$\mu g\ NO_3^-$-N/g	
Days	0-3 cm	5-20 cm	0-3 cm	5-20 cm
*				
2	15	1	11	5.2
4	-	-	-	-
6	17	0	17	5.2
8	15	1	12	17
10	8	0	5.8	17
12	14	1	5	15
14	25	2.3	26	23
16	84	5.8	42	19
18	322	27	114	38
20	627	60	118	44

* Initial NH_4^+-N added = 2333 μg/g.

Table 18. Nitrification potential; pretreatment, April 4, 1974, samples (Plot 23)

	$\mu g\ NO_2^-$-N/g		$\mu g\ NO_3^-$-N/g	
Days	0-3 cm	5-20 cm	0-3 cm	5-20 cm
*				
2	11	1	7	5
4	-	-	-	-
6	17	2	0	8
8	19	2	0	0
10	29	2	0	19
12	93	2	21	25
14	282	4	31	30
16	627	8	47	35
18	908	37	62	40
20	1233	90	72	51

* Initial NH_4^+-N added = 2333 μg/g.

Table 19. Nitrification potential; pretreatment, April 4, 1974, samples (Plot 24)

	$\mu g\ NO_2^-$-N/g		$\mu g\ NO_3^-$-N/g	
Days	0-3 cm	5-20 cm	0-3 cm	5-20 cm
*				
2	14	1	8	9
4	-	-	-	-
6	19	1	26	15
8	20	1	69	17
10	18	1	52	19
12	53	1	104	26
14	193	1	162	31
16	628	10	167	35
18	1450	38	238	46
20	1875	90	332	61

* Initial NH_4^+-N added = 2333 μg/g.

Table 20. Soil nitrogen analysis; August 8, 1974; 0-5 cm surface samples

Plot Sample	Fixed NH_4^+-N	Organic N	Exchangeable NH_4^+-N	NO_2^- + NO_3^--N
		µg N/g soil		
1	141	1869	1.4	15.4
2	126	1384	1.5	11.9
3	141	1440	1.4	13.6
4	106	1354	0.3	10.8
5	167	1863	3.6	19.5
6	117	1843	6.1	9.2
7	178	2123	2.8	17.9
8	582	1394	0.9	11.9
13	683	2073	1.4	-
14	131	2089	0.0	13.5
15	83	1727	1.5	14.7
16	123	2027	1.4	18.9
29	473	1975	2.7	14.1

Table 22. Nitrification potential; August 8, 1974, 0-5 cm surface samples

Day	µg NO_2^--N/g				µg NO_3^--N/g			
	Plot Numbers				Plot Numbers			
	1	2	3	4	1	2	3	4
*								
2	14	6	8	7	3	1	8	0
4	22	11	19	14	0	0	0	0
6	28	18	28	22	0	6	0	0
8	20	15	54	45	21	0	10	0
10	20	42	122	97	0	0	21	0
12	10	104	359	233	0	21	37	0
14	12	47	667	400		21	37	13
16	-	-	-	-	-	-	-	-
18	59	525	1333	950	104	68	62	34
20	123	817	1500	1475	130	78	213	37

* Initial NH_4^+-N added = 2333 µg/g.

Table 21. Soil pH values; August 8, 1974, 0-5 cm samples

Plot Sample	pH	Plot Sample	pH
1	8.5	8	8.5
2	8.8	13	8.5
3	8.4	14	8.8
4	8.5	15	8.8
5	8.4	16	8.9
6	8.8	29	8.4
7	8.6		

Table 23. Nitrification potential; August 8, 1974, 0-5 cm surface samples

Day	$\mu g\ NO_2^-$-N/g				$\mu g\ NO_3^-$-N/g			
	Plot Numbers				Plot Numbers			
	5	6	7	8	5	6	7	8
*								
2	18	7	8	6	0	0	0	0
4	25	21	17	12	0	5	10	5
6	37	33	20	17	0	5	23	31
8	46	112	14	14	0	5	36	0
10	87	242	23	29	21	10	57	0
12	154	533	47	68	21	12	73	6
14	223	1025	133	133	47	31	88	6
16	-	-	-	-	-	-	-	-
18	675	3583	750	817	167	62	167	2.8
20	825	1658	1183	1317	130	78	213	37

* Initial NH_4^+-N added = 2333 μg/g.

Table 24. Nitrification potential; August 8, 1974, 0-5 cm surface samples

Day	$\mu g\ NO_2^-$-N/g					$\mu g\ NO_3^-$-N/g				
	Plot Numbers					Plot Numbers				
	13	14	15	16	29	13	14	15	16	29
*										
2	6	4	2	4	5	8	0	0	0	3
4	-	-	-	-	-	-	-	-	-	-
6	14	23	12	23	13	0	5	5	0	0
8	13	41	21	35	15	21	10	8	0	0
10	8	98	36	113	3	5	28	0	26	0
12	15	202	80	227	14	26	0	-	21	10
14	18	337	172	546	28	21	21	35	26	0
16	14	812	343	983	71	-	42	52	74	47
20	49	1808	908	1592	521	40	115	104	162	52
22	122	858	1641	2175	1175	103	151	140	-	99

* Initial NH_4^+-N added = 2333 μg/g.

Table 25. Ammonia volatilization from N-Serve-treated soils

	$\mu g\ NH_3$ Volatilized			$\mu g\ NO_2^-$ and NO_3^--N/g dry soil	
	1 Week	2 Weeks	3 Weeks	Initial	Final
TREATMENT 1 (control soil)					
Artemisia	22.4	1.4	9.8	5.0	20.1
Ceratoides	64.4	7.0	7.0	5.0	57.4
Atriplex	126.6	42.0	32.2	5.0	27.3
TREATMENT 2 (soil + ^{15}N-ammonium sulfate)					
Artemisia	45.45	14.7	13.3	5.0	25.9
Ceratoides	317.80	19.6	25.9	5.0	50.75
Atriplex	287.70	52.5	112.0	5.0	17.85
TREATMENT 3 (soil + ^{15}N-ammonium sulfate + N-Serve)					
Artemisia	110.6	58.8	35.7	5.0	82.6
Ceratoides	395.5	205.8	179.2	5.0	53.2
Atriplex	717.5	517.3	296.8	5.0	46.2

Table 26. Soil pH values; July 2, 1975, 0-5 cm surface soil samples

Plot Sample	pH	Plot Sample	pH
4	8.0	16	8.2
3	7.9	19-20	8.2
1	8.8	17-18	8.4
5-6	8.3	21-22	9.4
13	8.2	23	8.6
7-8	8.7	24	8.1
14-15	8.4		

Table 27. Nitrogen analysis of field N-Serve-treated, perfused soil; July 2, 1975, 0-5 cm samples*

	μg NH_4^+-N/g soil		μg NO_2^- + NO_3^--N/g soil	
Plot Sample	Control	2 mg/g $(NH_4)_2SO_4$ added	Control	2 mg/g $(NH_4)_2SO_4$ added
4	1140	3323	18.1	4.6
3	2758	1003	18.6	13.0
1	1092	5593	18.8	17.4
13	1683	5071	15.0	19.4
14-15	271	4844	10.3	20.4
16	2325	617	24.4	0.00
19-20	925	4831	19.7	4.6
17-18	846	4415	21.7	0.00
21-22	1022	1230	50.4	25.7
23	700	2286	9.3	50.6
24	297	5886	16.7	5.2
Ave.	1187	3554	20.3	14.6
7-8 (No N-Serve)	576	1284	14.6	41.5

*Soils analyzed after 20-day perfusion.

Table 28. Total N in soil; 0-5 cm surface samples

Plot	July 2, 1975 mg N/g Soil	August 8, 1974 mg N/g Soil
4	2.19	2.145
3	1.70	1.51
1	2.21	--
5-6	2.19	--
13	2.07	2.11
7-8	1.96	2.22
14-15	1.77	2.015
16	1.90	2.15
19-20	2.62	--
17-18	2.20	2.02
21-22	1.92	--
23	2.42	--
24	1.53	--
Ave.	2.05	2.02

DISCUSSION

The rate of applied N-Serve was increased from 560 to 840 g N-Serve/ha for the October 1974 and the April, June and October 1975 applications because the August 8, 1974, samples failed to show its presence as judged from biological tests. In addition, no change in the soil N fractions (organic N, exchangeable and fixed NH_4^+—N, or NO_2^-— and NO_3^-—N) was observed. It is evident that, due to the extreme dryness and high soil surface temperature during the 1974 summer, the N-Serve had volatilized off from the soil surface.

From the data given in Table 25, the loss of volatilized N-Serve is again suggested, as the highest levels of NO_2^-— and NO_3^-—N are found in the N-Serve-treated soils. However, as the total ammonia volatilization in these soils is also high and the rate of volatilization does not drop off after the first week of incubation, it may be presumed that, initially, the N-Serve is blocking nitrification. Futhermore, as the soil dries, the N-Serve is lost due to volatilization, thus allowing the ammonium ion to be available to the nitrification process. This suggests that for N-Serve to be effective, it has to be applied and maintained in the field in the rainy and wet periods which coincide with the highest activity of N_2 fixation by blue-green algae and with the degradation of its products. Data presented in Table 27 suggest, however, that significant retention of NH_4^+ may occur in soils due to inhibition of nitrification throughout the season.

Since the application of N-Serve during 1975 was initiated at the start of and continued during the spring rainy season in Utah, the loss of volatilized N-Serve does not appear to be as severe as in 1974. Since only four samples had less than the initial NH_4^+ concentration in soil, and the treated soils had lower NO_2^-— and NO_3^-—N values per gram of soil than in the control soils, it suggested that not all of the surface-applied N-Serve was lost due to volatilization, but effectively remains in the soil. Furthermore, the data in Table 14 indicate a slight increase in total N from August 8, 1974, to July 2, 1975. The spraying of N-Serve will be continued during the rainy seasons of the year.

During the fall season of 1975, it was noted that the site had been invaded with *Halogeton*. The crested wheatgrasses (Siberian and Fairway varieties), which were seeded in 1974, have sprouted and are competing with the invading *Halogeton*. However, the grasses are not tall, but short and stubby, suggesting the possibility of herbivore feeding by the native jackrabbit.

It is expected that a blue-green algae crust, native to the area, develops and considerable amounts of fixed nitrogen will be stabilized (immobilized) by the application of organic materials to soil. This would increase organic matter in soil with a subsequent improvement of soil structure forming a slow-releasing nitrogen pool, useful for plant nutrition.

It is possible that, under the conditions of our treatments, denitrification may take place, i.e., with an ultimate loss of total nitrogen and carbon. This process may be inhibited by the addition of N-Serve, which prevents formation of NO_2^- (and NO_3^-), an essential step in the denitrification process, thus reducing the amount of nitrate available for denitrification during the period of ammonium incorporation in the organic matter.

It is expected that increased retention of nitrogen and subsequent buildup of organic matter in soil will beneficially affect the yield of crested wheatgrass (*Agropyron cristatum*), the test plant.

The results of these treatments may be used to test several aspects of the proposed nitrogen cycle model.

The project is expected to be continued to its successful conclusion with non-IBP support.

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