Nitrate-Nitrogen Status of Fallowed Rangeland Soils[1]

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Highlight

Nitrate-nitrogen (NO_3-N) accumulated in the soil during the spring, summer, and fall of a fallow year. NO_3-N levels in the surface 6 inches in fall, 1967 and 1968, were similar and averaged 43 lb./acre on the atrazine fallow, 27 lb./acre on the mechanical fallow, and 5 lb./acre on the check. Above average precipitation during the winter of 1968–69 resulted in less NO_3-N in spring, 1969 compared to spring, 1968. A comparison between the 2 years at one location showed the following NO_3-N levels in the surafce 6 inches: spring, 1968—atrazine fallow 30 lb./acre, mechanical fallow 29 lb./acre, and check 13 lb./acre; spring, 1969—atrazine fallow 5 lb./acre, and check 2 lb./acre.

An atrazine fallow shows promise for establishment of perennial grasses on rangeland infested with downy brome (*Bromus tectorum*) (Eckert and Evans, 1967). Atrazine at 1 lb./acre is fall-applied and perennial grasses seeded a year later. During the fallow year, annual weeds are controlled by the soil-active herbicide and soil moisture is conserved. Martin and Leonard (1967) point out that fallowing also promotes nitrification. The objective of this study was to determine the nitrate-nitrogen (NO_3-N) status of fallowed, semi-arid, rangeland soils.

Methods and Materials

Seven study sites were in the big sagebrush (*Artemisia tridentata*) type but are now dominated by downy brome, tumble mustard (*Sisymbrium altissimum*), Russian thistle (*Salsola kali* var. *tenuifolia*), and pepperweed (*Lepidium perfoliatum*). A fallow was accomplished by either: (1) 2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine (atrazine) at 1 lb./acre applied in fall, 1966 and 1967; or (2) mechanical treatment in June, 1967 and 1968. New fallows were established each year. Treatment plots 20 by 20 ft were replicated four times. During the spring, summer, and fall of fallow years, soil samples were collected from depths of 0–1, 0–3, 3–6, 6–9, and 9–12 inches. The following spring, sample depths were 0–3, 3–6, 6–12, 12–18, and 18–24 inches. Samples were air dried for 1 day in the greenhouse, screened to pass a 2 mm sieve, and stored at –20 F until analyzed by the phenyldisulfonic acid method (Chapman and Pratt, 1961).

Results and Discussion

NO_3-N Accumulation During the Fallow Year

Figure 1 presents the NO_3-N status of the surface 6 inches of soil on the atrazine fallow and check during the fallow years of 1967 and 1968 at the Trap Butte and Orovada sites. These data are from a new fallow each year.

The NO_3-N level was significantly higher on the fallow at each sample date. A similar trend was found on other sites (Table 1). More NO_3-N accumulated during spring, 1967 than during spring, 1968 on two sites studied in both years. This difference was probably due to more rapid nitrification in 1967 since precipitation and weed control data indicate that leaching and utilization of NO_3-N by weeds would be minimal factors in nitrate loss. Data from one location indicate that nitrate accumulation in 1969 was similar to that in 1968.

NO_3-N accumulation began early in 1967 and 1968. For example, in 1968 on one site accessible for sampling on February 15, the surface 6 inches contained 9 lb./acre NO_3-N on the atrazine fallow compared to 5 lb./acre on the check. Data from seven sites show that the average NO_3-N in the surface 6 inches on April 1 was 17 lb./acre on the atrazine fallow and 8 lb./acre on the check. Table 1 gives similar comparisons for all collection dates. By April 1, 74% of the spring-accumulated NO_3-N in the surface 6 inches on the atrazine fallow had been produced; by May 1, 78%; and by May 28, 87%.

From April through May, 65 to 74% of the NO_3-N in the surface 3 inches was found in the 0- to 1-inch sample. However, by the middle of June 67% of the NO_3-N in the surface 3 inches was below 1 inch. From 70 to 78% of the NO_3-N in the surface 6 inches was found in the 0- to 3-inch sample.

The final soil sample was collected after annual species had matured. Precipitation from convectional storms in July and August 1968 moistened the soil and nitrification occurred until soil temperature became too cold. Without plant growth, NO_3-N accumulated on both fallow and check treatments with few exceptions. This resulted in similar NO_3-N concentrations in the 0- to 6-inch sample (Fig. 1), and in the 0- to 12-inch sample (Table 2) by fall, 1967 and 1968. Without summer precipitation in 1968, NO_3N in the final sample that year would have been less than in 1967.

A comparison of atrazine and mechanical fallows showed significantly more NO_3-N accumulation in the former. One month after mechanical treatment a 0- to 6-inch sample contained 26 lb./acre

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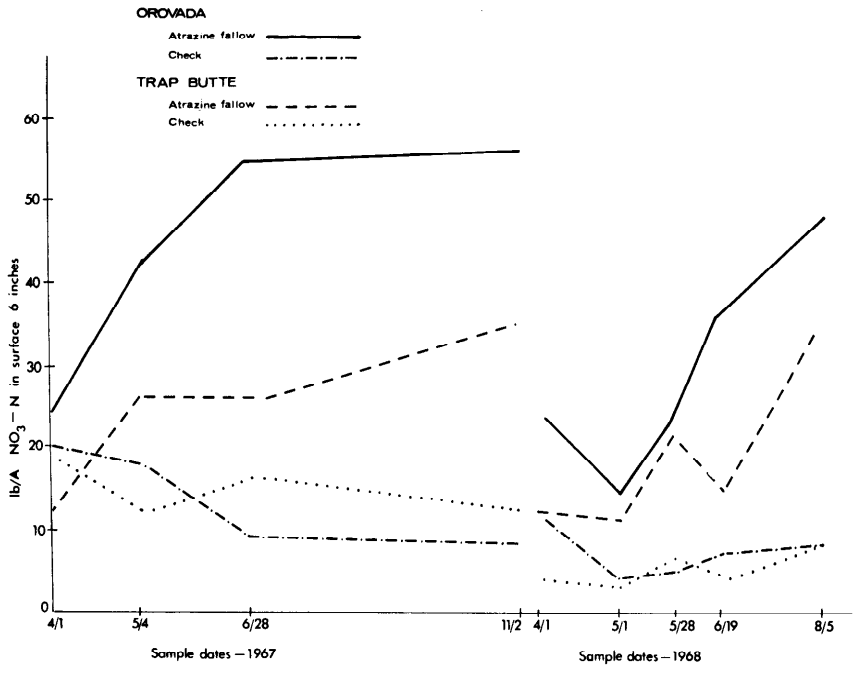

FIG. 1. Pounds per acre of NO_3-N in the surface 6 inches of soil on an atrazine fallow and check on two sites in 1967 and 1968.

NO_3-N; the atrazine fallow had 55 lb./acre NO_3-N. The major reason for this difference was that the nitrification process in the atrazine fallow had been operative since late winter or early spring. Conversely, annual species continued to use nitrogen until killed by mechanical fallow treatment. After mechanical treatment, NO_3-N can accumulate if weed control is successful and if adequate soil moisture remains or summer precipitation occurs. For example, in November 1967, NO_3-N in the surface 6 inches at Orovada was 56 lb./acre on the atrazine fallow and 53 lb./acre on the mechanical fallow (Table 2). However, poor weed control on a mechanical fallow or growth of summer annuals after mechanical fallow will result in less NO_3-N accumulation than on an atrazine fallow. In 1967 at Trap Butte, growth of summer annual plants on the mechanical treatment reduced NO_3-N in the surface 6 inches by 8 lb./acre from time of

Table 1. NO_3-N (lb./acre) in the 0–6-inch depth on the check and atrazine fallow on four sample dates averaged for seven locations in 1968.

Date	NO_3-N	
	Check	Atrazine fallow
4/1	8	17
5/1	4	18
5/28	4	20
6/19	4	23

Table 2. NO_3-N (pounds/acre) in fall 1967 and 1968, and in spring 1968 and 1969 on atrazine fallow, mechanical fallow, and check.[1]

Location and treatment	Depth, inches											
				Total						Totals		
	0–3	3–6	6–12	0–12	0–3	3–6	6–12	12–18	18–24	0–12	12–24	0–24
	– Sampled Oct. 31, 1967 –				– – – – – – Sampled March 20, 1968[2] – – – – – –							
Trap Butte												
Atrazine fallow	19	16	8	43	7	6	18	9	10	31	19	50
Mechanical fallow	6	8	9	23	6	6	13	4	3	25	7	32
Check	7	5	5	17	5	2	4	4	3	11	7	18
Orovada												
Atrazine fallow	46	10	17	73	15	15	47	12	14	77	26	103
Mechanical fallow	44	9	16	69	13	16	38	14	11	67	25	92
Check	4	4	9	17	7	6	20	3	4	33	7	40
	– Sampled Aug. 5, 1968 –				– – – – – – Sampled April 28, 1969 – – – – – –							
Trap Butte												
Atrazine fallow	28	6	11	45	3	1	5	2	2	9	4	13
Check	5	4	5	14	1	1	1	1	1	3	2	5
Orovada												
Atrazine fallow	41	6	11	58	3	2	4	11	9	9	20	29
Check	6	2	5	13	1	1	2	1	1	4	2	6

[1] Atrazine at 1 lb./acre was applied in separate experiments in fall, 1966 and 1967. Mechanical treatment was made in June, 1967.
[2] Samples from 12–18 and 18–24 inches were collected in June and July after leaching from winter and spring precipitation had ceased.

treatment in June until November. On an atrazine fallow with no summer weeds, NO_3-N increased by 9 lb./acre during the same period. If annual plants utilize most of the available soil moisture before mechanical treatment, or if precipitation after treatment is sparse and soil is dry, nitrification will be suppressed (Alexander, 1965) and NO_3-N will not accumulate. For example, after a very dry spring and summer in 1968, NO_3-N in the 0- to 6-inch sample on the last sample date at Orovada was 47 lb./acre on the atrazine fallow, about the same as in 1967, compared to only 13 lb./acre on the mechanical fallow.

NO_3-N in Soil the Spring After a Fallow Year

At this time of year perennial grasses are in the seedling stage. The amount of NO_3-N varied with year, treatment, location, and depth (Table 2). Precipitation during the winter of 1967–68 was 4 to 5 inches at both Trap Butte and Orovada. An average of 31% of the total NO_3-N in the surface 24 inches of soil was found in the 0- to 6-inch sample. At Trap Butte on March 20, NO_3-N in a 0- to 3-inch sample was similar on both the fallow and check treatments. However, the 3- to 6-inch sample from the fallows contained significantly more NO_3-N (6 lb./acre) than did the check (2 lb./acre). At Orovada on March 20, NO_3-N was greater in fallowed soils (14 and 15 lb./acre respectively, in the 0- to 3 and 3- to 6-inch samples) than on the check (7 and 6 lb./acre, respectively). NO_3-N will continue to accumulate during the spring of the seedling year if weeds are not present. For example, in June at Orovada, NO_3-N in the surface 3 inches averaged 30 lb./acre on the fallows and 3 lb./acre on the check.

An average of 41% of the total NO_3-N in the surface 24 inches of soil was found in the 6- to 12-inch sample. NO_3-N in this sample was significantly higher on the atrazine fallow (38 lb./acre) and mechanical fallow (26 lb./acre) than on the check (12 lb./acre).

Samples from 12 to 18 and 18 to 24 inches each contained 14% of the total NO_3-N in the surface 24 inches of soil. Average NO_3-N in the 12- to 18-inch sample was 10 lb./acre on the atrazine fallow, 9 lb./acre on the mechanical fallow, and 4 lb./acre on the check. Average NO_3-N in the 18- to 24-inch sample was 12 lb./acre on the atrazine fallow, 7 lb./acre on the mechanical fallow, and 4 lb./acre on the check.

Precipitation in the Orovada-Trap Butte area from October to the initial spring sample date was 11 to 12 inches in 1968–69, compared to 4 to 5 inches in 1967–68, and to the long term average of 7 to 8 inches. NO_3-N data for spring, 1969 reflect this difference in winter precipitation (Table 2). The atrazine fallows at Trap Butte and Orovada contained 45 and 58 lb./acre NO_3-N, respectively, in the surface 12 inches of soil in fall, 1968. From 50 to 71% of this NO_3-N was leached below 24 inches by spring 1969. Only 9 lb./acre NO_3-N were found in the surface 12 inches of the atrazine fallow at each site. At Orovada the 12- to 24-inch sample contained 20 lb./acre NO_3-N; at Trap Butte only 4 lb./acre NO_3-N were found.

As in 1968, NO_3-N accumulated in the 0- to 3-inch depth on treated plots during spring, 1969. Average levels at seven locations were: April 28—fallow 5 lb./acre, check 2 lb./acre; May 12—fallow 12 lb./acre, check 1 lb./acre; and June 9—fallow 10 lb./acre, check 2 lb./acre.

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