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The Interspecific Differences for Absorption of Nitrate and Nitrite by Alfalfa and Smooth bromegrass from some Nitrogen Compounds

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Introduction

Increases of yield owing to the applications of some nitrogen compounds application have frequently been reported for forage plants in the north area of Japan, and the yield responses range from 50 to 400 kg N/ha. However, the effects of nitrogen are responsed by the complex interactions of moisture, aeration, temperature, the nature and quantity of organic matter, the nature and quantity of the previous plant residue, and other physical chemical, and biotic soil properties[1].

In most soils dominated by 2 : 1 clay minerals, chlorine (Cl) is very mobile and is greatly affected by the amount and rate of water moving through the soil. Soil chlorine (Cl) behaves similarly to nitrate nitrogen in soils, though it does not undergo biological or chemical transformation[2].

In a study on silt loam in Wisconsin planted with alfalfa (*Medicago sativa* L.), nitrate nitrogen and chlorine moved an average of 46 cm per year with 61 to 84 cm of precipitation per year[3].

Nitrogen mineralization is a key process in supplying nitrogen for plant growth. Nitrogen compounds such as NH_4Cl, $(NH_4)_2SO_4$, and NH_4NO_3 applied for alfalfa and smooth brome grass (*Bromus intermis* LEYSS.) are effective to increase of herbage yield. Therefore, we use those nitrogen compounds for forage plants. However, those nitrogen compounds are absorbed in the form of nitrite, nitrate, ammonium, urea, peptide, amino acids form, and so on by the plants.

On the other hand, forage accumulates nitrite or nitrate from the soil or culture solution, which is a hindrance to the health of mammals.

We reported that the absorptions of some cations and anions by alfalfa and orchardgrass from soils or culture solutions were effected with those ions contents in the soil or culture solution[4,5]. We reported also, that those ions absorbed were related homologous series of ions, the relationship being a negative correlation among those cations or anions[6].

Some reports have successfully established a relationship between nitrogen

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compounds applied to the soil and nitrate concentrations in herbage[7,8]. However, few studies have documented interspecific differences of nitrite or nitrate absorption by alfalfa and smooth bromegrass in the same soil. Thus, the objective of this study was to confirm the concentration and amounts of nitrite and nitrate in alfalfa and smooth bromegrass on the establishment stage field added NH_4Cl, $(NH_4)_2SO_4$, or NH_4NO_3.

Materials and Methods

The study was carried out in the field. The soil used was Nopporo diluvial soil. The chemical characteristics of the soil prior to the initiation of the experiment are shown in Table 1. The soil had pH (H_2O) 6.0 and (KCl) 4.9. The content of total nitrogen was 0.39 per cent, and available phosphorous was a lower content of 5.4 mg/100 g dry soil. The nitrate extracted by 1 : 5 soil : water in the soil was 1.48 mg/100 g dry soil. Soluble (0.1 N HCl) Zn, Mn, and Cu, contents were 1.8, 30.0, and 0.3 mg/1000 g dry soil, respectively.

The amounts of basic fertilizers applied to the plots are shown in Table 2. The fertilization was done using chemical fertilizer. The size of each plot was 1 m^2, and the treatments were in three repetitions. Alfalfa (*Medicago sativa* L.)

Table 1. Chemical characteristics of soil used

Kind of Soil	pH		EC	T-N	NO_3-N	Available		Exchangeable bases			Trace elements			
						P_2O_5	K_2O	Na_2O	CaO	MgO	Zn	Mn	Cu	B
	H_2O	KCl	mmho	%	1:5 Soil: Water mg/100 g	mg/100 g dry soil					ppm Dry matter basis			
Diluvial soil	5.5	4.9	0.88	0.33	1.48	6.2	12.0	6.1	196.0	28.3	2.7	34.0	6.0	0.26

Table 2. Amounts of fertilizers

a. Basic Fertilizers

Type of fertilizer	g/m^2	g/m^2
Super phosphate	10	2 as P_2O_5
Potassium sulfate	40	20 K_2O
Calcium carbonate	60	336 CaO
Fused magnesium	20	3 MgO

b. Amounts of Nitrogen Fertilizers

Type of Nitrogen	Chemical formula	Amount of N g/m^2
Ammonium chloride	NH_4Cl	
Ammonium sulfate	$(NH_4)_2SO_4$	0, 5, 10 and 40 as N
Ammonium nitrate	NH_4NO_3	

cultivar Bartas and smooth bromegrass (*Bromus inermis* LEYSS.) cultivar Salatoga were grown on those soils plots with the same basic fertilizers, and were added by five level of three nitrogen compounds, that is 0, 5, 10, 20, and 40 g/m² as N of ammonium chloride, ammonium sulfate, and ammonium nitrate, respectively.

Both plants were harvested at the first-flower stage of the alfalfa. After the 1st cutting, were applied to amounts of 1/2 basic nitrogen compounds were applied to each plot, and the both regrowth plants were sampled at the 1, 2, 5, and 7th weeks. The herbage and soils were analyzed for nitrite, nitrate and total nitrogen. The determination of anions in the plants and soils was carried out using the Dionex ion chromatography.

Results and Discussion

Dry matter yield of alfalfa and smooth bromegrass:

The dry matter yields of alfalfa and smooth bromegrass are shown in Table 3. The dry matter yields of alfalfa and smooth bromegrass on 1st cutting in the 1st year increased from the 0-plot to the 20-plot, but decreased with on increase of nitrogen added. The average amounts of alfalfa dry matter were 216, 244, and 264 g/m² from the ammonium chloride, ammonium sulfate and ammonium nitrate plots, respectively, while, for smooth bromegrass were 52.5, 53.0, and 53.9 g/m².

Table 3. Dry matter yield of alfalfa and smooth bromegrass

May 3. Seeding, July 24. Harbest.

Plant hight (cm)	Alfalfa	Smooth bromegrass
Ammonium chloride	23.8	25.5
Ammonium sulfate	34.4	25.8
Ammonium nitrate	36.4	26.0
Fresh weight (kg/m²)		
Ammonium chloride	1.08	0.68
Ammonium sulfate	1.22	0.71
Ammonium nitrate	1.32	0.75
Dry matter yield (g/m²)		
Ammonium chloride	216	52.5
Ammonium Sulfate	244	53.0
Ammonium nitrate	264	53.9

Total nitrogen, nitrate, and nitrite concentrations in both plants;

The concentrations of total nitrogen, nitrate, and nitrite in both plants are shown in Table 4 and Fig. 1 a and 1 b. The concentrations of total nitrogen in alfalfa were from 2.45 on the 0-plot to 3.22% on the 40-plot for ammonium chlo-

Table 4. The concentrations of total nitrogen, nitrate and nitrite of both plants

	as N (g/m^2)	a. alfalfa Total-N	a. alfalfa Nitrate-N (%)*	a. alfalfa Nitrite-N	b. smooth bromegrass Total-N	b. smooth bromegrass Nitrate-N (%)	b. smooth bromegrass Nitrite-N
NH_4Cl	0	2.45	0.002	0	3.35	0.013	0
	5	2.40	0.008	—	3.58	0.142	—
	10	3.30	0.027	—	3.42	0.293	—
	20	3.26	0.038	—	3·58	0.420	—
	40	3.22	0.134	22**	3.11	0·356	47**
	average	2.93	0.042		3.41±1.74	0.245	
$(NH_4)_2SO_4$	0	3.15	0.001	0	3.48	0.111	0
	5	2.90	0.010	—	3.37	0.182	—
	19	3.15	0.047	—	3.40	0.422	—
	20	2.35	0.092	—	3.15	0.418	—
	40	2.99	0.099	21	3.41	0.489	38
	average	2.91	0.050		3.36±1.12	0.324	
NH_4NO_3	0	3.31	0.009	0	3.04	0.050	0
	5	3.30	0.011	—	3.26	0.070	—
	10	3.35	0.050	—	3.59	0.203	—
	20	3.26	0.107	—	3.58	0.408	—
	40	3.26	0.175	12	3.28	0.635	37
	average	3.30	0.070		3.35±2.10	0.301	
		3.04±0.36	0.054±0.053		3.37±1.72	0.281±0.179	

* Dry matter basis, 2nd cutting in 1st year ** ppm

ride. The concentrations of total nitrogen in alfalfa were from 3.15 on the 0-plot to 2.99% on the 40-plot for ammonium sulfate, and 3.31 and 3.26%, respectively for ammonium nitrate. The concentrations of total nitrogen in smooth bromegrass were from 3.35 on the 0-plot to 3.11% on the 40-plot for ammonium chloride. The concentrations of total nitrogen in smooth bromegrass were from 3.48 on the 0-plot to 3.41% on the 40-plot for ammonium sulfate, and 3.04 and 3.28%, respectively for ammonium nitrate.

The concentrations of nitrate in alfalfa were from 0.002 on the 0-plot to 0.134% on the 40-plot for ammonium chloride, 0.001 and 0.099%, respectively, for ammonium sulfate, and 0.009 and 0.175%, respectively for ammonium nitrate. The concentrations of nitrate nitrogen in smooth bromegrass were from 0.013 on the 0-plot to 0.356% on the 40-plot for ammonium chloride, and 0.111 and 0.489%, respectively, for ammonium sulfate, and 0.050 and 0.635%, respectively, for ammonium nitrate.

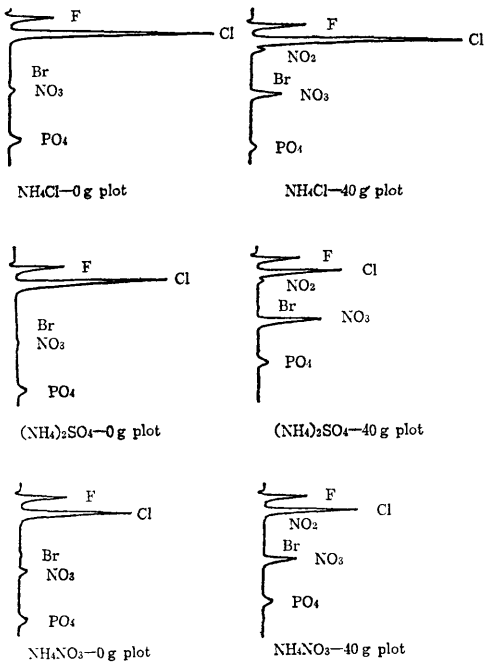

Fig. 1 a. Nitrate and nitrite concentrations in the alfalfa plant on 7 weeks after 1st cutting.

At establishment stage, nitrogen of 0, 5, 10, 20 and 40 g/m² added to each plot, and after 1sd cutting, amounts of 1/2 of basal fertilizers of nitrogen added to each plot.

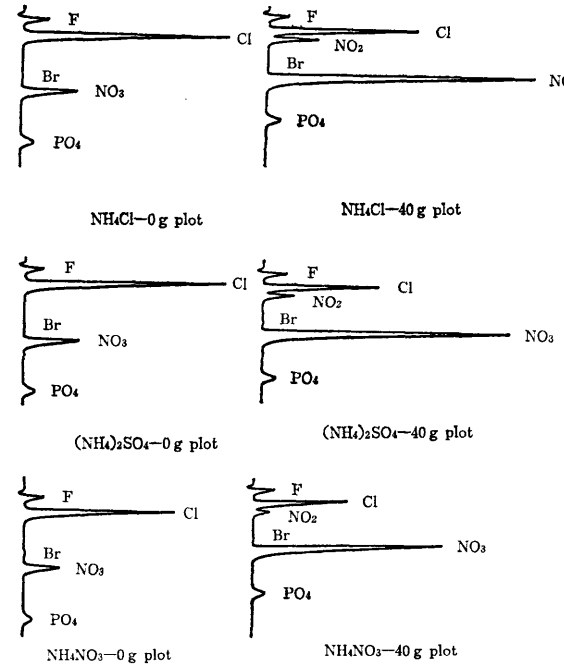

Fig. 1 b. Nitrate and nitrite concentrations in the smooth bromegrass plant on 7 weeks after 1st cutting.

At establishment stage, nitrogen of 0, 5, 10, 20 and 40 g/m² added to each plot, and after 1st cutting, amounts of 1/2 of basal fertilizers of nitrogen added to each plot.

Table 5. Interspecific difference of total-N, NO_3-N and NO_2-N absorption

	alfalfa			smooth bromegrass		
	T-N**	NO_3-N**	NO_2-N*	T-N**	NO_3-N**	NO_2-N*
NH_4Cl	2.93	0.042	22	3.41±1.74	0.245	47
$(NH_4)_2SO_4$	2.91	0.050	21	3.36±1.12	0.324	38
NH_4NO_3	3.30	0.070	12	3.35±2.10	0.301	37
Average	3.04±0.36	0.054±0.053	—	3.37±1.72	0.281±0.179	—

* 40-plot only ppm. ** %

The concentrations of nitrite in alfalfa were from 0 the on 0-plot to 22 ppm on the 40-plot for ammonium chloride, 0 and 21 ppm for ammonium sulfate, and 0 and 12 ppm for ammonium nitrate.

The concentrations of nitrite in smooth bromegrass were from 0 on the 0-plot to 47 ppm on the 40-plot for ammonium chloride, 0 and 38 ppm for ammonium sulfate, and 0 and 37 ppm, respectively, for ammonium nitrate.

The interspecific difference of total-N, nitrate-N and nitrite-N absorption in

alfalfa and smooth bromegrass is shown in Table 5. As can be seen in the table the average concentration of total-N for alfalfa plants was 3.04±0.36% while the average for smooth bromegrass was 3.37±1.72%. The total-N concentration in smooth bromegrass was higher than that of alfalfa. The concentration of nitrate-N in the alfalfa plants was 0.05±0.053% and that of the smooth bromegrass plants was 0.281±0.179%. The concentration of nitrate in the smooth bromegrass was higher than that of alfalfa. The concentration of nitrite, was also high in smooth bromegrass. Therefore, the quality of alfalfa plants was considered more favorable than smooth bromegrass as forage for cows.

The mineral concentrations of both plants:

The mineral concentrations of alfalfa and smooth bromegrass are shown in Tables 6 a and 6 b. As can be seen in the table, the average concentration of phosphate (P_2O_5) in alfalfa was 0.48±0.14%, and in smooth bromegrass was 0.46 ±0.04%, with no difference with in the kind of nitrogen compounds added. The average concentration of calcium (CaO) found in the alfalfa was 2.56±0.23%, and in smooth bromegrass was 0.97±0.15%. The calcium concentrations were higher in

Table 6. The mineral concentration in both plants

a. alfalfa

	as N (g/m^2)	P_2O_5	CaO	MgO	K_2O	Na_2O
		% (Dry matter basis)				
NH_4Cl	0	0.59	2.83	0.24	2.25	0.06
	5	0.41	2.55	0.24	3.50	0.09
	10	0.49	2.83	0.20	3.55	0.10
	20	0.39	2.41	0.32	3.75	0.14
	40	0.46	2.05	0.38	3.85	0.31
	average	0.47±0.07	2.53±0.29	0.28±0.07	3.38±0.58	0.14±0.09
$(NH_4)_2SO_4$	0	0.40	2.50	0.22	2.80	0.14
	5	0.38	2.16	0.14	3.30	0.12
	10	0.42	2.70	0.12	3.50	0.22
	20	0.42	2.86	0.32	3.55	0.16
	40	0.94	2.38	0.42	4.90	0.12
	average	0.51±0.22	25.2±0.24	0.24±0.11	3.61±0.70	0.15±0.04
NH_4NO_3	0	0.59	2.70	0.36	2.80	0.12
	5	0.43	2.50	0.10	4.30	0.04
	10	0.48	2.75	0.10	3.30	0.15
	20	0.39	2.70	0.24	3.55	0.21
	40	0.46	2.52	0.42	2.25	0.43
	average	0.47±0.07	2.64±0.10	0.24±0.13	3.24±0.69	0.19±0.13
		0.48±0.14	2.56±0.23	0.26±0.11	2.25±0.68	0.16±0.10

b. smooth bromegrass

	as N (g/m^2)	P_2O_5	CaO	MgO	K_2O	Na_2O
		% (Dry matter basis)				
NH_4Cl	0	0.54	1.06	0.12	4.35	0.27
	5	0.46	0.81	0.26	6.10	0.87
	10	0.48	1.04	0.18	6.70	0.02
	20	0.40	1.26	0.04	7.55	0.45
	40	0.50	1.29	0.12	6.10	0.27
	average	0.48±0.05	1.09±0.17	0.14±0.07	6.16±1.05	0.38±0.28
$(NH_4)_2SO_4$	0	0.44	0.81	0.30	5.05	0.03
	5	0.46	0.98	0.44	5.40	0.87
	10	0.50	0.98	0.24	6.45	0.02
	20	0.46	0.84	0.28	6.00	0.02
	40	0·48	0.84	0.21	6.30	0.15
	average	0.47±0.02	0.89±0.07	0.29±0.08	5.84±0.53	0.22±0.33
NH_4NO_3	0	0.40	0.84	0.26	3.85	0.02
	5	0.37	1.01	0.10	3.85	0.03
	10	0.47	0.87	0.32	3.85	0.67
	20	0.46	0.95	0.24	6.10	0.09
	40	0.48	0.90	0.28	2.30	0.41
	average	0.44±0.04	0.91±0.06	0.24±0.08	3.99±1.21	0.24±0.26
		0.46±0.04	0.97±0.15	0.23±0.10	5.33±1.37	0.28±0.30

alfalfa plants than that of smooth bromegrass plants, but the difference with the kind of nitrogen compounds added was not detected in both plants. The concentrations of magnesium (MgO) in alfalfa was 0.26±0.11%, and in smooth bromegrass was 0.23±0.10%. The concentrations of magnesium, in alfalfa did not increase with the rising of nitrogen compounds, but there was no difference in the kind of nitrogen compounds used. The concentration of potassium (K_2O) in alfalfa was 2.25±0.68%, and in smooth bromegrass was 5.33±1.37%. There was no clear variation in the potassium concentrations with respect to the kind of nitrogen compounds added. The concentration of sodium in alfalfa was 0.16±0.10 %, and in smooth bromegrass was 0.28±0.30%.

The chemical characteristics in the soils after the harvest of both plants:

The chemical characteristics in the soils after the harvest of the alfalfa and smooth bromegrass are shown in Tables 7 a and 7 b. As can be seen, the pH value in the soils decreased with the addition of the nitrogen compounds in Table 8 a and 8 b. The content of available phosphate in the soils increased, and that of exchangeable calcium in the soils decreased with the addition of nitrogen compounds.

Table 7. Chemical characteristics of the soils after harvest of both plants

a. alfalfa

	as N	pH		EC	T-N	P_2O_5	CaO	MgO	K_2O	Na_2O	Zn	Mn	Cu
	g/m^2	H_2O	KCl	$\mu s/cm$	%	mg/100 g dry soil					ppm Day matter basis		
NH_3Cl	0	5.77	5.33	0.09	1.45	6.73	227.0	10.0	28.0	11.8	2.3	20.5	5.0
	40	5.01	4.61	0.09	1.15	9.04	103.7	10.0	14.8	9.3	4.0	33.0	6.5
$(NH_4)_2SO_4$	0	5.85	5.49	0.11	0.10	6.73	252.2	6.0	41.5	6.0	5.1	17.5	5.0
	40	4.60	4.38	0.17	0.80	8.65	78.5	6.0	31.5	8.3	3.8	21.0	5.5
NH_4NO_3	0	5.74	5.75	0.10	0.45	5.77	271.8	22.0	15.6	9.0	3.1	16.5	4.0
	40	4.91	5.83	0.13	0.20	8.17	134.5	8.0	21.0	9.0	2.9	24.9	4.8

b. smooth bromegrass

	as N	pH		EC	T-N	P_2O_5	CaO	MgO	K_2O	Na_2O	Zn	Mn	Cu
	g/m^2	H_2O	KCl	$\mu s/cm$	%	mg/100 g dry soil					ppm Dry matter basis		
NH_4Cl	0	5.43	5.23	0.12	1.05	7.21	227.0	8.0	32.8	9.50	2.8	20.5	4.0
	40	5.00	4.51	0.23	1.15	8.65	148.6	8.0	26.0	9.25	3.4	25.0	6.5
$(NH_4)_2SO_4$	0	5.67	5.52	0.14	0.70	6.73	266.2	16.0	43.0	9.50	2.1	17.5	2.0
	40	5.00	4.53	0.19	0.10	11.50	143.0	14.0	25.3	9.50	4.2	21.0	4.5
NH_4NO_3	0	5.75	5.45	0.12	0.30	5.81	288.6	18.0	14.3	10.00	3.0	16.5	3.0
	40	5.17	4.95	0.19	0.50	6.92	240.1	22.0	35.5	10.50	4.0	24.9	4.5

This lower value with addition of nitrogen compounds was considered due to nitrate in the soils, and the reduction of the pH value was the cause of the manganese increase in the soils. Therefore, the concentrations of manganese in both plants were increased as shown in Table 9. The relationship between the pH value in soils and manganese in both plants is shown in Fig. 2 a and 2 b. Namely,

Table 8. The change of pH value with addition of nitrogen compounds

a. alfalfa

		Amounts of compounds g/m^2					
		0	5	10	20	40	average
NH_4Cl	KCl	5.33	5.20	5.08	4.96	4.98	5.11±0.16
	H_2O	5.77	5.83	5.08	5.21	5.01	5.38±0.39
$(NH_4)_2SO_4$	KCl	5.49	5.89	5.40	4.91	4.97	5.33±0.40
	H_2O	5.85	6.40	5.62	5.72	5.20	5.76±0.43
NH_4NO_3	KCl	5.75	5.39	5.09	5.12	4.91	5.25±0.33
	H_2O	5.74	5.68	5.72	5.18	5.83	5.63±0.26

b. smooth bromegrass

		Amounts of compounds g/m²					
		0	5	10	20	40	average
NH_4Cl	KCl	5.23	5.29	4.80	4.93	4.51	4.95±0.32
	H_2O	5.43	5.87	5.17	5.77	5.00	5.45±0.37
$(NH_4)_2SO_4$	KCl	5.52	5.43	5.42	4.61	4.53	5.10±0.49
	H_2O	5.67	6.18	5.70	5.60	5.00	5.63±0.42
NH_4NO_3	KCl	5.45	5.52	5.22	5.22	4.95	5.27±0.22
	H_2O	5.75	5.89	5.98	5.40	5.17	5.64±0.34

Table 9. Concentration of Mn in both plants (ppm)

a. alfalfa

Nitrogen compounds added	Amounts of Nitrogen as N g/m²					average
	0	5	10	20	40	
NH_4Cl	52	38	60	73	75	59.6±15.3
$(NH_4)_2SO_4$	42	24	45	68	56	47.0±16.3
NH_4NO_3	40	38	40	54	54	45.2± 8.1
					total average	50.6±14.4

b. smooth bromegrass

Nitrogen compounds added	Amounts of Nitrogen as N g/m²					average
	0	5	10	20	40	
NH_4Cl	42	40	45	68	68	52.6±14.4
$(NH_4)_2SO_4$	36	21	40	66	53	43.1±17.3
NH_4NO_3	25	23	28	41	59	35.2±15.0
					total average	43.6±16.2

the pH value decreased with the increase of nitrogen compounds added, thus, the coefficoents of correlation were $r=-0.772$ for alfalfa, $r=-0.636$ for smooth bromegrass, and $r=0.678$ for both plants.

Summary

Alfalfa (*Medicago sativa* L.) and smooth bromegrass (*Bromus intermis* LEYSS.) were grown in test plots of Nopporo diluval soil. The soil plots had been previously fertilized with five levels of three different nitrogen compounds, namely, ammonium chloride, ammonium sulfate, and ammonium nitrate. The levels of nitrogen added to the plots were 0, 5, 10, 20, and 40 g/m² as N. Both plants were harvested at the first-flower stage of the alfalfa. After the 1st culting, the plots were fertilized with amounts of 1/2 basic nitrogen on each plot, and both

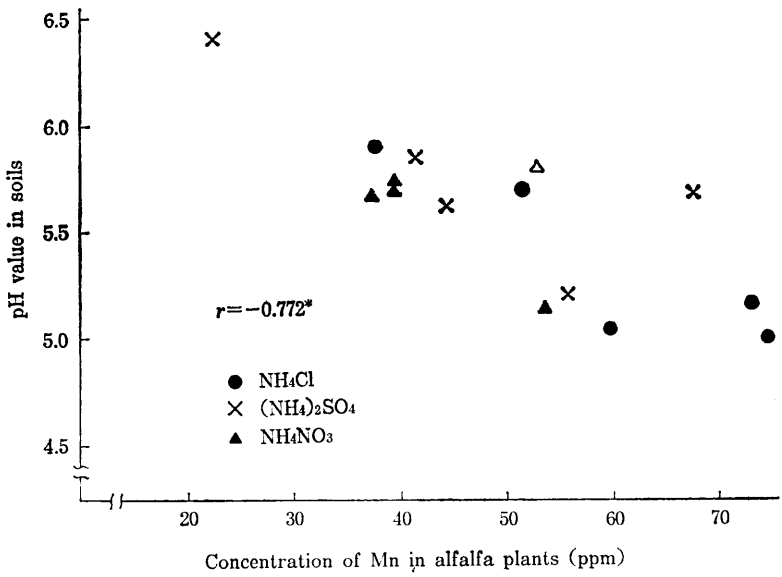

Fig. 2 a. The relationship between pH(H_2O) value and Mn concentration in alfalfa. * Singnificant at the 0.01 probability level.

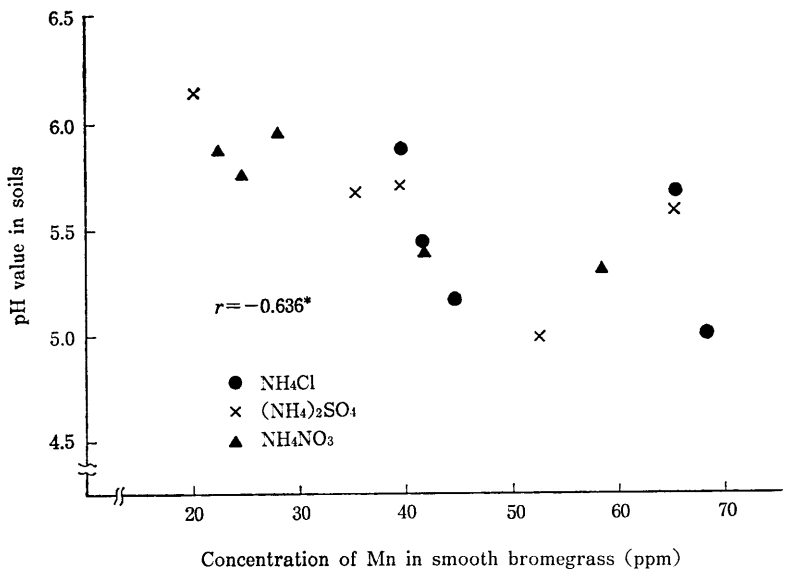

Fig. 2 b. The relationship between pH(H_2O) value and Mn concentration in smooth bromegrass. * Significant at the 0.01 probability level.

plants were regrown and the plants were sampled at the 1, 2, 5, and 7th weeks after the 1st cutting. The herbage and soils were analyzed for nitrate, nitrate and total nitrogen.

The main results were as follow ;

1) The dry matter yield of alfalfa and smooth bromegrass from the 1st cutting

Table 10. The contents of nitrate and nitrite in the soils added nitrogen compounds (ppm of nitrite, dry matter soil basis)

a. alfalfa Sampling on 7 weeks after 1st cuuting.

	Amounts of compounds g/m²				
	0	5	10	20	40
NH_4Cl	1.40 (0)*				4.06 (0)*
$(NH_4)_2SO_4$	1.88 (0)				2.31 (0)
NH_4NO_3	3.75 (0)				1.90 (0.37)

b. smooth bromegrass

	Amounts of compounds g/m²				
	0	5	10	20	40
NH_4Cl	7.05 (12.5)*				26.80 (0)*
$(NH_4)SO_4$	2.98 (0)				0.92 (0)
NH_4NO_3	1.31 (0)				5.45 (0)

* Numerals of ( ) are nitrate contents in soils.
Sampling in Sep. 13, 1989.

of the 1st year were increased from the 0-plot to the 20-plot, but decreased with the increase of nitrogen compounds added. The average amounts of dry matter were 216, 244, and 264 g/m² on the ammonium chloride, ammonium sulfate and ammonium nitrate plots, respectively, while, the average amounts were 52.5, 53.0, and 53.9 g/m² for smooth bromegrass.

2) The concentrations of total nitrogen in both plants increased with the increment of nitrogen compounds added from 2.45 on the 0-plot to 3.41% on the 40-plot. The concentrations of nitrate in the alfalfa plants also, ranged from 0.001 on the 0-plot to 0.175 on the 40-plot, and in smooth bromegrass ranged from 0.013 on the 0-plot to 0.635% on the 40-plot. The nitrite concentrations in both plants with increasing addition of nitrogen compounds was unlike especially, that in smooth bromegrass was higher than that in alfalfa.

3) The mineral concentrations in both plants did not differ with kinds and amounts of nitrogen compounds.

4) The chemical characteristic in the soils after the harvest of both plants were as follows; the pH value in the soils had decreased with the addition of nitrogen compounds, as had the content of exchangeable calcium in the soils. The low pH value and calcium decrease were considered due to nitrate increase in the soils. As a result of this decrease, and therefore, indirectry as a result of the increase of nitrogen compounds added the concentrations of manganese in both plants gradually increased.

5) The relationship between the pH value in soils and manganese in both plants was $r=-0.675$ ($p<0.01$) and individually, $r=-0.772$ ($p<0.01$) for alfalfa, and $r=-0.636$ ($p<0.01$) for smooth bromegrass.

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要　　約

アルファルファ (*Medicago sativa* L.) とスムースブロムグラス (*Bromus inermis* LEYSS.) を，二・三の窒素化合物の5つのレベルの施用によって生育させた，すなわちその土壌は野幌洪積土壌であり，窒素化合物は塩化アンモニウム，硫酸アンモニウム，あるいは硝酸アンモニウムであった。

各試験区に加えられた窒素の量はNとして0, 5, 10, 20, そして40 g/m² であった。この二種類の植物はアルファルファの第1花期で収穫された。この1番草の刈取り後，この試験区には初期の窒素化合物施用量の1/2量を施用した。そしてこの植物は再生長させ，そして1, 2, 5および7週後に採取された。その牧草と土壌は硝酸，亜硝酸および全窒素の分析に供された。

主な結果は以下のようであった。

1) 1年目1番草のアルファルファとスムースブロムグラスの乾物収量は窒素化合物の施量用の増加に伴ない0-区から20-区にむかって増大した。しかしそれ以上の施用では減少した。塩化アンモニウム，硫酸アンモニウムおよび硝酸アンモニウムの施用によるアルファルファの平均乾物収量はそれぞれ，216，244および264 g/m² であり，一方のスムースブロムグラスでは52.5，53.0そして53.9 g/m² であった。

2) 両植物の全窒素の含有率は加えられた窒素化合物の増加によって，0-区の2.45から40-区の3.41%まで増大した。またアルファルファの硝酸含有率は0区の0.001から40区の0.175%であった。そしてスムースブログラスの硝酸含有率は0区0.013区から40区の0.635%であった。両植物中に，窒素化合物の増大した添加で亜硝酸が確認された。とくに，スムース

ブロムグラスではアルファルファより一層高含有率であった。

3) 両植物の無機成分は窒素化合物の量や種類で変化がなかった。

4) 両植物の刈取後の土壌の特性は以下のようであった。すなわち，pH の窒素化合物の添加で低下した。そしてまた，置換性のカルシウムも減少した。この pH 低下とカルシウムの減少は硝酸の増加のためと考えられた。そしてそのため土壌の窒素化合物増大で植物体中のマンガンの含有率が増大した。

5) この pH とマンガンの相関は，両植物で $r=-0.675$ ($p<0.01$) であり，アルファルファでは $r=-0.772$ ($p<0.01$)，そしてスムスブログラスでは $r=-0.636$ ($p<0.01$) であった。