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The Absorption Characteristics of some Selenium Compounds applied to Alfalfa and Smooth bromegrass

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Introduction

Selenium has been shown to be an essential micro-nutrient for mammals, birds, and several bacteria[1,2]. Various selenium containing amino acids occur in nature and play important physiological roles[3,4]. Interactions between dietary sulphur and selenium in the ruminants have been subject of several investigations since it was first suggested by Schubert[5] that high dietary intakes of sulphur may increase the incidence of selenium responsive myopathy in grazing sheep. However, subsequent studies have indicated that in sheep, the effects of dietary sulphur on selenium metabolism are not always demonstrable and, when present, are unlikely to have pathological relevance.

Investigation of the effects of sulphur on selenium metabolism in the rat have been more limited than those in the ruminant. Sulfate added to the diets of rats has been shown to counteract the toxic effects of excess dietary selenate. On the other hand, in a study of pasturized milk from different areas in New Zealand, 3-fold variation from the highest to the lowest areas was found, reflecting the selenium status of the soils and pasture of these areas[6].

Harada et al. (1984)[7] reported that the concentration of sulphur in the alfalfa increased with sulphur fertiliser and a negative correlation $r = -0.932$ existed between the concentration of sulphur and selenium, but for orchardgrass there was no significant correlation was found.

Little attention has been paid to the absorption of selenium by plants from soils. Therefore, the object of this study was to determine the relation between selenium absorptions by plants and selenium compounds added to the soils.

Materials and Methods

The soil used was Nopporo diluvial soil. The chemical characteristics

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Table 1. Chemical characteristics of soil used

Soil	pH		EC	T-N	Available P_2O_5	Exchangeable bases				Trace elements			
						K_2O	Na_2O	CaO	MgO	Zn	Mn	Cu	B
	H_2O	KCl	mmho	%	mg/100 g soil	mg/100 g soil				ppm Dry matter basis			
Diluvial soil	6.0	4.9	0.60	0.39	5.4	8.5	0.5	159.0	14.0	1.8	30.0	0.3	0.26

Table 2. Amount of fertilizers and selenium compounds

1 Fertilizers

Kind of fertilizer	g/m^2		g/m^2
Urea	2.4	as N	5.0
Ammonium phosphate	32.3	as P_2O_5	20.0
Potassium chloride	23.8	as K_2O	15.0
Calcium carbonate	178.6	as CaO	100.0
Magnesium carbonate	42.0	as MgO	20.0
F·T·E	2.0		

2 Selenium compounds

1) Low addition

Kind of selenium	Chemical formula	Amounts of compound g/m^2	g/m^2
Selenious acid	H_2SeO_3	0.65	as Se 0.4
Selenic acid	H_2SeO_4	0.73	
Sodium selenite	Na_2SeO_3	0.95	
Sodium selenate	Na_2SeO_4	0.88	
Selenium dioxide	SeO_2	0.56	

2) High addition

Selenious acid	H_2SeO_3	6.53	as Se 4.0
Selenic acid	H_2SeO_4	7.35	
Sodium selenite	Na_2SeO_3	9.57	
Sodium selenate	Na_2SeO_4	8.76	
Selenium dioxide	SeO_2	5.62	

of the soil are shown in Table 1. The soil had pH (H_2O) 6.0 and (KCl) 4.9. Content of total nitrogen was 0.39 per cent, and available phosphorous was lower than 5.4 mg/100 g dry soil. The exchangeable K_2O was low value of 8.5 mg/100 g dry soil. And also the copper content of micro-elements was low values of 0.3 ppm dry soil basis.

The kinds of the selenium compound used were selenious acid H_2SeO_3, sodium selenite Na_2SeO_3, selenic acid H_2SeO_4, sodium selenate Na_2SeO_4 and selenium dioxide SeO_2.

The amount of basic fertilisers and amount of selenium compounds used are shown in Table 2. The size of each plots were 1 m^2, and the treatments were in three repetitions.

Alfalfa (*Medicago sativa* L.) and smooth bromegrass (*Bromus inermis* Leyss) were grown on these soils plots with same fertiliser and two level of selenium compounds.

Both plants were harvested at the first-flower stage of alfalfa. The herbage and soils were analyzed for selenium and other nutrients. Determinations of selenium in the soil and plants were carried out at 378 nm of excited wave-length and 250 nm of fluorescence wave-length using Hitachi 650-10S fluorescence spectro-photometer.

Results and Discussion

Plant growth and dry matter yield ;

The forage yield of alfalfa and smooth bromegrass were related to the levels of selenium added and to the types of selenium compounds. The plant length and dry matter yield of both plants decreased with the increase of selenium compounds added to the soils. While with the application of selenium compounds, selenic acid, sodium selenate compounds and sodium selenite inhibited plant growth compared to other compounds for plants growth.

Concentrations of selenium in the plants ;

The concentrations of selenium in the alfalfa and the smooth bromegrass forage were the highest for sodium selenate, secondly selenic acid and sodium selenite, and selenious acid and selenium dioxide were the lowest. Fig. 1 shows the results obtained in a comparison of the concentrations of forage with different selenium compounds added to the soils. The average concentrations in both plants ranged from 10 ppm to 45 ppm for high plots, and 2.5 to 28.6 ppm for low plots respectively. While the concentration of selenium for control plot was 0.04 ppm.

These data suggest that selenium concentrations in the forage crops directly increased with the selenium compound added to the soil. If this was true, it would be highly dangerous to feed cow or other bornyard animal, because high concentration of selenium in the feed over 1 ppm was poisonous to animals or cows[8].

Interspecific differences of selenium absorption ;

Interspecific differences of selenium absorption among selenium compounds were not clear. But Harada and Shinohara et al.[7] have reported that selenium concentrations in alfalfa and orchardgrass grown on four

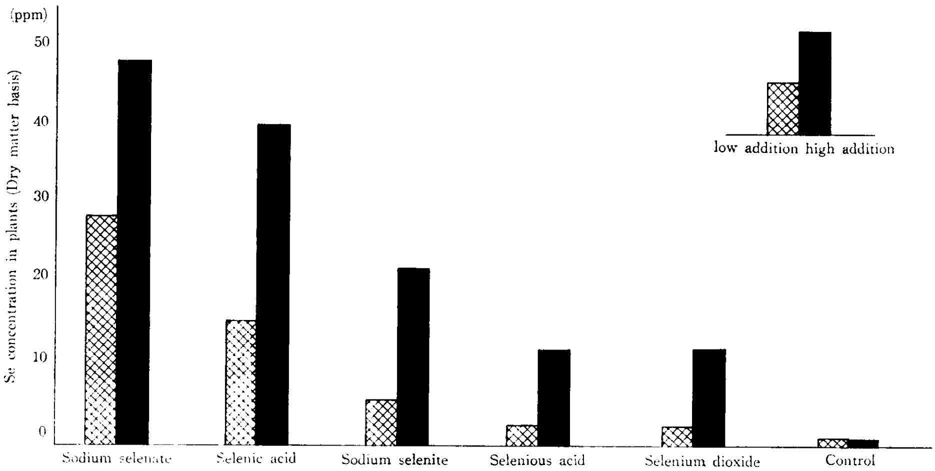

Fig. 1. Relationships between Se compounds to soil and Se concentration in plants.

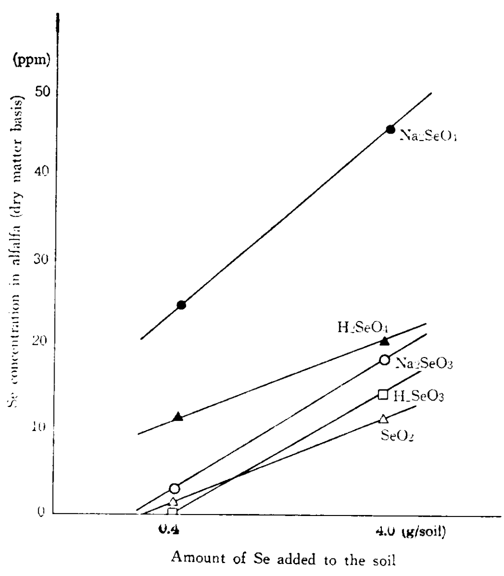

Fig. 2. Relationships between amount of Se added to the soil and Se concentration in plants.

Table 3. Kind of selenium compounds used and valence

Type of compounds	Valence	Chemical formula
Selenious acid	(+4)	H_2SeO_3
Selenic acid	(+6)	H_2SeO_4
Sodium selenite	(+4)	Na_2SeO_3
Sodium Selenate	(+6)	Na_2SeO_4
Selenium dioxide	(0)	SeO_2

Table 4. Selenium content of soil (ppm)

	Type of Se compounds	Kind of soil	
		after 1st cutting	after 2nd cutting
	Se-0	0.80	0.70
Low addition	H_2SeO_3	2.75	1.58
	H_2SeO_4	1.12	1.23
	Na_2SeO_3	3.07	4.54
	Na_2SeO_4	2.22	2.78
	SeO_2	4.93	3.26
High addition	H_2SeO_3	20.24	11.96
	H_2SeO_4	4.25	3.75
	Na_2SeO_3	14.69	12.66
	Na_2SeO_4	4.85	1.12
	SeO_2	40.60	38.50

different soils were significantly different in the two plants species. The concentration of selenium in the alfalfa plant was eight-fold of that in the orchard grass on the pumice volcanic soil. Fig. 2 shows the relationships between the amount of selenium added to the soil and selenium concentration in the plants. It was considered that selenium compounds of 6 valence was absorbed easily more than other selenium compounds by the plants. These valence are shown Table 3.

The selenium contents of the soil grown plant ;

Table 4 show the selenium contents of the soil harvested for plants. The contents of selenium in the soil with selenic acid H_2SeO_4 and sodium selenate Na_2SeO_4 were lower, and were higher in the soil added selenious acid H_2SeO_3, sodium selenite Na_2SeO_3, and selenium dioxide SeO_2. These responses were considered by valence of selenium compounds, namely the selenium compounds of polyvalence were absorbed more than that of zero or few valence.

Summary and Conclusion

Alfalfa (*Medicago sativa* L.) and smooth bromegrass (*Bromus inermis* Leyss) were grown on Nopporo diluvial soil, with some selenium compounds applied to the soil, namely, selenious acid H_2SeO_3, sodium selenite Na_2SeO_3, selenic acid H_2SeO_4, sodium selenate Na_2SeO_4 and selenium dioxide SeO_2. The plants were harvested, and were determined for forage yield and were analysed for mineral composition, especially selenium concentration.

The main results were as follows;

1) The concentration of selenium in the forage and content of the soil increased with the increment of selenium compounds added to the soils. While selenium compounds of H_2SeO_4, Na_2SeO_3 and Na_2SeO_4 inhibited the growth of plants more than H_2SeO_3 and SeO_2.

2) The concentrations of selenium in the forage were the highest for Na_2SeO_4, secondly H_2SeO_4 and Na_2SeO_3, and were the lowest for H_2SeO_3 and SeO_2 added to the soils.

3) Interspecific differences of selenium absorption among selenium compounds were not clear.

4) The selenium contents of the soil harvested for plants were lower in the soil with H_2SeO_4 and Na_2SeO_4, and were higher in the soil with H_2SeO_3, Na_2SeO_3 and SeO_2.

In conclusion, the readily absorbable selenium compound was sodium selenate Na_2SeO_4 and non-absorbable selenium compound was selenium dioxide SeO_2.

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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* Leyrs) が数種の異なるセレニウム化合物の施用された野幌洪積土壌に生育させられた。すなわち，セレニウム化合物は亜セレン酸 H_2SeO_3，セレン酸 H_2SeO_4，亜セレン酸ナトリウム Na_2SeO_3，セレン酸ナトリウム Na_2SeO_4 および二酸化セレン SeO_2 である。

この植物体は収穫され，ミネラル組成とくにセレニウム含有率が分析された。その主要な結果は以下のようであった。

1) この牧草のセレニウム含有率は土壌に加えられたセレニウムの増加で高まった。一方 H_2SeO_4，Na_2SeO_3 と Na_2SeO_4 は H_2SeO_3 や SeO_2 よりもこの植物生育を阻害した。

2) この牧草のセレニウムの含有率は Na_2SeO_4 で最も高くついで H_2SeO_4 と Na_2SeO_3 であり，最も低いのが H_2SeO_3 と SeO_2 であった。

3) セレニウム化合物についての吸収における牧草種間差は明瞭ではなかった。

4) この植物が収穫された後の土壌のセレニウム含量は H_2SeO_4 と Na_2SeO_4 で低く，H_2SeO_3，$NaSeO_3$ そして SeO_2 でより高かった。

結論として，容易に吸収されるセレニウム化合物はセレン酸ナトリウム Na_2SeO_4 であり，吸収されずらいのは二酸化セレン SeO_2 であった。