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The Absorption Characteristics of selenious Acid applied to Corn (*Zea mys* L.)

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Introduction

Selenium has been shown to be an essential micro-nutrient for mammals, birds and several bacteria (Stadman, 1978, Scott, 1973)[1,2], but selenium has not been shown to be an essential micro-nutrients for higher plants. The selenium absorbed by plant was uptaken by dairy cattle and becomes one of constituents elements in glutathione peroxidase in the living body. Namely, the glutathione peroxidase include 4 selenium atoms in one molecule. Also, the mean daily amounts of selenium (72 μg) seemed to be adequate compared with the Dutch Nutrition Council suggestions (Voedingsraad, 1986)[3]. Total-diet studies as defined and recommended by the FAO/WHO (WHO, 1976, 1985) have been carried out for many years in the USA (Johnson et al. 1984)[4], the UK (Peattie et al. 1983)[5] and other countries (Gorchev and Jelinik, 1985)[6]. Total-diet studies are also suitable for evaluating the nutritional quality of national diets. 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 (Millar, 1973)[7].

We (Harada et al. 1984)[8] reported that the concentration of sulphur in the alfalfa increased with sulphur fertilizer and a negative correlation $r=-0.932$ existed between the concentration of sulphur and selenium, but for orchardgrass there was found no significant correlation. We reported (Harada et al. 1987)[9] also that for absorption of some selenium compounds by alfalfa and smooth bromegrass existed, and the main absorbable selenium compound was sodium selenate Na_2SeO_4 and non absorbable selenium compound was selenius dioxide SeO_2.

In the present paper we report the results of the relationships between selenium concentrations in corn (*Zea mays* L.) and selenium contents in the soil, especially, for the fertilization to the soil or for stages of growth and parts of the corn.

Materials and Methods

The soil used in this study was Nopporo diluvial soil. Chemical characteristics of the soil prior to experimental initiation were 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 content of 5.4 mg/100 g dry soil. The exchangeable

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K_2O was low value of 8.5 mg/100 g dry soil. Also, the copper content of micro-elements was low values of 0.3 ppm dry soil basis.

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

This study was carried out in the field. The amount of basic fertilizers and amount of selenious acid H_2SeO_3 added to the plots were shown in Table 2. Fertilization was done by barnyard manure plus chemical fertilizer, chemical fertilizer and non fertilizer plots. The size of each plots was 1 m^2, and the treatments were in three repetitions.

Table 2. Amounts of fertilizers and selenious acid

a. Fertilizers

Type of fertilizer	g/m^2	g/m^2
Ammonium sulfate	25.0	5.0 as N
Super phosphate	75.0	15.0 P_2O_5
Potassium sulfate	27.8	15.0 K_2O
Calcium carbonate	53.6	30.0 CaO
Magnesium carbonate	3.2	1.5 MgO
Barnyard Manure	5 kg/m^2	

b. Selenious compounds and amounts

Type of selenium	Chemical formula	Amounts of compound g/m^2	
Non addition of Selenious acid		0	0 g/m^2 as Se
High addition of Selenious acid	H_2SeO_3	4.89	3.0

Corn (*Zea mays* L.) (variety; pioneer 85 and new dent 105) was grown on these soils plots with different fertilizations and two levels of selenium. Density of planting was row space of 70 cm and inter-row space of 30 cm, also was thined one plant after 48 days of seeding.

These plants were harvested at milk-ripe and ripening stage of corn. It was 70 days after seeding of variety pioneer 85 and 88 days of new dent 105 to attain the milk-ripe stage. Both varieties were harvested 140 days after seeding for ripening stage. The plants and the soils were analysed for selenium and other nutrients. Determinations of selenium in the plants and soils were carried out at 378 nm of excited wave-length and 250 nm of fluoresence wave-length using Hitachi 650-10S fluorescence spectro-photometer.

Results and Discussion

Selenium contents in the soil used;

Selenium contents of diluvials soil used were shown in Table 3. The values were significantly different with selenium addition or non addition, but were not different with chemical fertilizer or barnyard manure. Namely, selenium content of non fertilization plots was 0.674±0.042 ppm without selenium, and 3.305±0.867 ppm with selenium.

The growth of corn in these soils was normal, even if selenium was added.

Table 3. Selenium contents in soils

Diluvial soil		Contents of Se in soil (ppm)
Non fertilizer plots	Se no addition	0.674±0.042
	Se addition	3.305±0.867
Chemical fertilizer plots	Se no addition	0.374±0.025
	Se addition	3.580±0.528
Chemical fertilizer plus Barnyard manure plots	Se no addition	0.713±0.014
	Se addition	3.451±0.675

Concentrations of selenium in the corn plants;

The average concentrations of selenium in the corn grown in all plots was 0.350±0.386 ppm, and it was 0.030±0.070 ppm in the plots without selenium, but it was 0.657±0.325 ppm in the plots with selenium. These results were shown in Table 4.

Table 4. Concentration of selenium in corn

Treatments	ppm
In all plots	0.350±0.386
Plot without Se	0.030±0.070
Plot with Se	0.657±0.325

These data suggest that selenium concentrations in the corn plants directly increased with the selenious acid added to the soil. We had found the same things in alfalfa plants and smooth bromegrass, previously (Harada et al. 1988)[10].

The concentrations of selenium at two stages of corn;

Selenium concentrations at milk-ripe and ripening stage are shown in Table 5. The concentrations of selenium in corn without selenium showed no difference at stages of growth, but those of corn with selenium were higher at milk-ripe stage than ripening one.

According to NRC (1978)[11], dairy cattle requires about 0.1 ppm selenium in the ration. The requirment also is appreciably influenced by the chemical form

Table 5. The concentrations of selenium at two stages of corn

	plot without Se	plot with Se
Milk-ripe stage	0.030±0.003 ppm	0.706±0.034 ppm
Ripening stage	0.028±0.003 ppm	0.612±0.071 ppm

of selenium and the levels of interacting factor in the ration including vitamin E, sulphur, lipids, amino acids and several micro-elements (Ammerman and Miller, 1975)[12].

Difference of selenium concentrations in two varieties;

The concentrations of selenium in pioneer 85 and new dent 105 without selenium were 0.029±0.004 and 0.028±0.020 ppm, respectively. The difference of selenium concentration in both varieties did not appear. Those of selenium in pioneer 85 and new dent 105 with selenium were 0.659±0.251 and 0.660±0.088 ppm, respectively. Also, the difference of selenium concentrations in corn with selenium was not clear.

Difference of selenium concentrations in the parts of corn;

The concentrations of selenium in the parts of corn were shown in Fig. 1. The distribution of selenium concentrations of corn without selenium was 0.035± 0.002 ppm in leaves, 0.027±0.002 ppm in stems and 0.026±0.001 ppm in seeds. The concentrations of corn with selenium were 0.936±0.051 ppm in leaves, 0.293± 0.041 ppm in stems and 0.751±0.056 ppm in seeds. The orders of selenium cocentrations in the parts was leaves>seeds≧stems.

We (Harada et al. 1984)[8] reported that, selenium contents with the different soils and selenium concentrations in alfalfa and orchardgrass grown on these soils

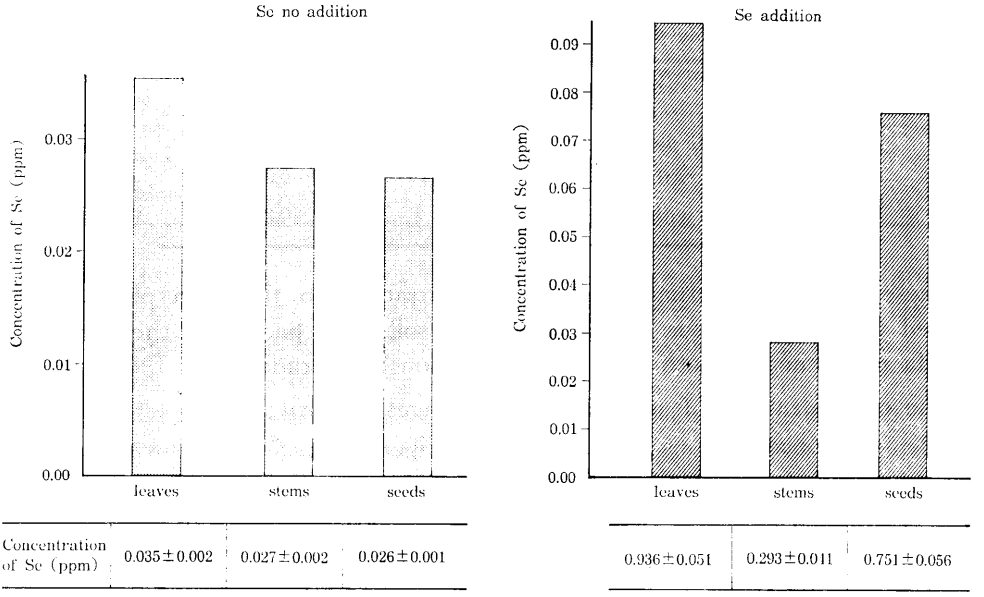

Fig. 1. Concentration of Se in the parts of corn

were significantly different in types of soils and also for the two plants species. Dokkum et al. (1989)[13] reported that high selenium values were observed in the group nuts (370 μg/kg), fish (370 μg/kg), meat and meat products (135 μg/kg) and poultry and eggs (190 μg/kg).

The concentrations of selenium in corn with different fertilization ;

The selenium concentrations in corn with different fertilizations were shown in Table 6, namely, these fertilizations were non-fertilizer, chemical fertilizer and chemical fertilizer plus barnyard manure. The average concentrations of selenium in corn grown on all non-fertilizer plots were 0.029±0.002 ppm, those of chemical fertilizer plots were 0.029±0.004 ppm and those of chemical plus barnyard manure plots were 0.031±0.003 ppm. All plots were not added selenious acid.

Table 6. Selenium consentrations of corn with fertilization (ppm)

	without Se	with
Se non-fertilizer	0.029±0.002	0.592±0.167
Chemical fertilizer	0.029±0.004	0.672±0.194
Chemical plus barnyard manure	0.031±0.003	0.715±0.186

In all plots added selenium, the concentrations of selenium in corn were higher than these of plots without selenium. The selenium concentration, that is, was 0.592±0.167 ppm in non-fertilizer plots, 0.672±0.194 ppm in chemical fertilizer plots and 0.715±0.186 ppm in chemical plus barnyard manure plots.

Summary

Corn (*Zea mays* L.) was grown on Nopporo diluvial soil, with selenious acid, namely, the amounts of Se were 0 g and 3 g/m² in the soils. The treatments of fertilization were non-fertilizer, chemical fertilizer and barnyard manure plus chemical fertilizer application. The plants were harvested, and Se was analysed.

The main results were as follows ;

1) The Se contents in soils of non-fertilization plots were 0.674±0.042 ppm without Se, and 3.305±0.867 ppm with Se.

2) The average concentrations of Se in the corn grown on all plots were 0.350± 0.386 ppm, and it was 0.030±0.070 ppm in the plots without Se, but is was 0.657± 0.325 ppm in the plots with Se.

3) Se concentrations at milk-ripe and ripening stage were not different for corn without Se, but those of corn with Se were higher at milk-ripes than ripening stage.

4) The concentrations of Se in pioneer 85 and new dent 105 without Se were 0.029±0.004 and 0.028±0.020 ppm, respectively. While those of Se in pioneer 85 and new dent 105 with Se were 0.659±0.251 and 0.660±0.088 ppm.

5) The distribution of Se concentrations of corn without Se was 0.035±0.002 ppm in leaves, 0.027±0.002 ppm in stems and 0.026±0.001 ppm in seeds. The concentrations of corn with Se were 0.936±0.051 ppm in leaves, 0.293±0.041 ppm in

stems and 0.751±0.056 ppm in seeds. This order of Se concentrations in the parts was leaves>seeds≧stems.

6) The average concentrations of Se in corn grown on all non-fertilizer plots were 0.029±0.002 ppm, those of chemical fertilizer plots were 0.029±0.004 ppm and those of chemical plus barnyard manure plots were 0.031±0.003 ppm. The above grown on all plots were not added Se. In all plots added with Se, the Se concentrations were 0.592±0.167 ppm in non-fertilizer plots, 0.672±0.194 ppm in chemical fertilizer plots and 0.715±0.186 ppm in chemical plus barnyard manure plots.

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要　　約

トウモロコシ (*Zea mays* L.) がそのセレン酸吸収を明らかにするため，野幌洪積性重粘土壌に播種された。施用した Se の量は 0 と 3 g/m^2 である。施肥処理は無肥料，化学肥料および化学肥料＋厩肥区である。これらの植物は収穫され Se が分析された。その主な結果は以下のようであった。

1) 無肥料区の Se 無施用土壌の Se 含量は 0.674±0.042 ppm であり，Se 無施用区土壌では 3.305±0.867 ppm であった。

2) 全区のトウモロコシの平均 Se 含有率は 0.350±0.386 ppm であり，Se 無施用区の場合は 0.030±0.070 ppm，そして Se 施用区の Se 含有率は 0.657±0.325 ppm であった。

3) Se 無施用区のトウモロコシの乳熟期と成熟期の Se 含有率には差異は認められなかったが，しかし Se 施用区では成熟期のものより乳熟期において高かった。

4) Se 無施用区のパイオニア 85 とニュデント 105 種の Se 含有率はそれぞれ，0.029±0.004 と 0.028±0.020 ppm であった。一方 Se 施用区の Se 含有率は 0.659±0.251 と 0.660±0.088 ppm であった。

5) Se 無施用区のトウモロコシの Se 含有率の部位別分布は，葉部で 0.035±0.002 ppm，茎部で 0.027±0.002 ppm，そして子実で 0.026±0.001 ppm であった。Se 施用区の Se 含有率は葉部で 0.936±0.051 ppm，茎部で 0.293±0.041 ppm，そして子実で 0.751±0.056 ppm であった。この部位による Se 含有率の順位は，葉部＞子実≧茎部であった。

6) すべての無肥料区のトウモロコシの Se の平均含有率は 0.029±0.002 ppm であり，化学肥料区のそれでは 0.029±0.004 ppm，そして化学肥料と厩肥施用区のそれにおいては 0.031±0.003 ppm であった。これらはすべて Se 無施用区のものであった。Se の施用されたすべての区の Se 含有率は無肥料区で 0.592±0.167 ppm であり，化学肥料区で 0.672±0.194 ppm であった。また化学肥料＋厩肥区では 0.715±0.186 ppm であった。