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A study on Se application for improving the soil in the environment at lower Se level

Wang Xiuying,[1] Ren Shangxue[1], Liu Wunong[1], Li Jiyun[2]

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Abstract — A result that application of sodium selenite or fly ash to some of soil in loess plateau can increase Se content in wheat grain has been demonstrated by the pot and field experiments, and added Se in soil can last its availability for 3 years. So this is a good measure for improving the low Se soils and preventing the Kaschin-Beck disease.

Keywords: Selenium; Sodium selenite; Kaschin-Beck disease.

For the past more than 20 years, the geographical and medical workers have carried out extensive surveys on Keshan disease and Kaschin–Beck disease. The results indicate that both these diseases are epidemic in the zone with the dominant brown soil series from northeast China to southwest China. The environmental features of disease affected regions are the extremely low Se contents in water, soils and crops so that Se contents in the bodies of the local inhabitants who live mainly on local grains are at the extremely low level. In addition, a great deal of achievement has been made by studying the disease-causing mechanism due to low Se contents and the disease prevention and treatments (Li Jiyun, 1982). So far orally administrating Se pellets (sodium selenite) to the local inhabitants, adding Se to the table salt, or spraying selenite solution over crop leaf surface to raise Se contents in grain can have an obvious effect upon the disease prevention and treatment, and may also reap great social benefits (Liang Shutang, 1982; Wang Zhilun, 1983). Nevertheless, there still exist drawbacks of the above methods for supplementing Se to human body. Since oral Se pellets and Se salts are made of inorganic Se and have a very narrow adaptible range to strictly administrate Se drugs and to monitor Se contents require a great deal of work to be done. In addition, though selenite solution sprayed over crop leaf surface can be absorbed by crops and converted into organic selenium, and Se contents in grains of current crops can be increased. It is difficulty to popularize this method in the dry faming areas where water resource is lacking. Therefore, based on the experience that application of Se to soils so as to increase Se contents in forage crops can control and treat Se deficient diseases in animals (Grant, 1965; Gupts, 1975; Watkinson, 1967b). We hold that Se can also be applied to soil to supplement organic selenium to human body through grains. This would be of great significance in the prevention and treatment of the two kinds of endemic diseases, mentioned above, if it is in the case. For this reason, the experiments of applying Se to soils had been carried out to raise Se contents in wheat grains during the period of 1983-1986, and the important results were obtained.

EXPERIMENTAL DESIGN AND ITS OBJECTIVES

The tests consist of both pot and field experiments. Two kinds of material were used as selenium fertilizers. One was sodium selenite, and the other was fly ash from a heat power

[1] Northwestern Institute of Soil and Water Conservation, Academia Sinica, Yangling, Shaanxi, China.

[2] Research Center for Eco–Environmental Sciences, Academia Sinica, Beijing, China.

plant. The fly ash with total Se 8.49 ppm and water soluble Se 0.75 ppm from the Hanchen Heat and Power Plant in Shaanxi province were selected as Se supplementary raw materials. The application of Se in both kind of experiments was the same. The application of sodium selenite was conducted at three levels: 75, 150 and 225 grams of sodium selenite per hactare, equivalent to 34.5, 69 and 103.5 of Se per hectare, respectively. The application of fly ash was carried out at four levels: 5625, 11250, 22500 and 45000 kg of fly ash per hectare, equivalent to 48, 96, 190.5 and 382.5 g of Se per hectare, respectively. Every experiment was conducted with a control without Se application. Each pot experiment had five replications and each field experiment had three replications.

The objective of pot experiment is to study the effects of different materials containing Se and different amount of Se application upon the increase of Se contents in wheat grains. Soils used in the experiments were Bicolour soil (Loess–clad red, colloid earth) and Red soil (old Loess) distributed in farmland in the Kaschin–Beck disease sone in Yongshou county, Shaanxi province. Their properties and Se contents are shown in Table 1.

Table 1 Basic soil properties and Se background values in pot and field experiments

Experiment types	Soil types	Sampling depths, cm	Organic matter, %	$CaCO_3$, %	pH	Total Se, ppb	Water soluble Se, ppb
Pot experiment	Bicolor soil	0-30	1.15	6.60	8.35	108	1.17
	Red soil	0-30	1.95	3.02	8.25	90	3.12
Field experiment	Shan soil	0-30	1.46	6.25	8.25	98	1.69

Since the two kinds of soil, content of Se very low were used in Se applicaton experiments having great practical significance. Soils in 0–30 cm depth layer in farmland were air dried and broken, and root system materials were removed. After seiving, soils were evenly mixed with sodium selenite or fly ash in the amount to be applied. Then, the mixtures were filled into plastic pots with 3.5kg of soil per pot. After being compacted, wheat was planted. During wheat growing period, soil in the pots should be kept to have 15% of moisture contents. Irrigation was carried out in stages by using deionized water based on this calculation. Wheat was sown in the middle of October 1983, with 6 plants per pot. Before sowing, 300 kg of N and P compound fertiliser per ha or 0.23 g to each pot was added. Urea was added as top dressing in tillering stage at 300 kg per ha or 0.23 g to each pot.

Field experiments were set on the sloping farmland at the disease affected village in the Yougshou County. Soil in the field is Shan soil (Loess–like entisol. Table 1), which spread widely on the Weibei Plateau, Shaanxi Province, containing low available Se. The objective of the experiment is to study the Se after effects in soil so as to determine the right years that once applying Se to farmland can last keeping to increase Se contents in wheat grains. At the end of September 1983, winter wheat was sown. Before sowing, different doses of sodium selenites and fly ash were evenly added to subsoil. Winter wheat was harvested in 1984, 1985, and 1986, respectively, and Se contents in wheat were determined.

EXPERIMENTAL RESULTS

The following results were obtained through pot and field experiments:

It can be seen from pot experimental results that the application of sodium selenite or fly ash can improve total Se and water-soluble Se in two types of soils, and Se contents in wheat grains and plants are raised with increasing Se application (Table 2 and 3).

Table 2 Se contents in soils prior to sowing and posterior to harvesting in different treatments of Se application (ppb)

Experimental treatments		Loess-clad Red Colloid Earth				Mixed Loess & Red earth with Concretions			
		Prior to sowing		Posterior to harvesting		Prior to sowing		Posterior to harvesting	
		Total Se	Water-soluble Se	Total Se	Water-soluble Se	Total Se	Water-soluble Se	Total Se	Water-soluble Se
Control experiments		90	3.1	-	2.9	108	1.2	86	1.2
Sodium	75	136	4.7	125	4.1	108	2.5	90	2.4
selenite,	150	150	6.8	140	6.1	126	4.2	125	4.0
g/ha	225	157	8.1	145	7.4	164	5.6	142	5.4
	5625	126	4.0	115	3.3	103	3.3	105	3.1
Fly ash,	11250	153	5.1	140	4.7	131	4.3	126	4.2
kg/ha	22500	172	6.3	162	6.2	166	5.9	143	5.7
	45000	226	10.1	224	10.0	221	7.7	170	7.7

Table 3 Se contents in wheat plants and grains in pot experiment after Se applied (ppb)

Experimental treatments		Loess-clad Red Colloid Earth				Mixed Loess & Red earth with Concretions			
		seedling	heading plants	mature plants	grains	seeding	heading plants	mature plants	grains
Control experiments		24	29	29	13	19	32	36	13
Sodium	75	78	73	46	59	66	61	35	37
selenite,	150	164	104	63	165	114	69	46	74
added, g/ha	225	232	112	93	180	158	114	62	129
Fly	5625	52	47	27	34	45	30	26	24
ash,	11250	89	85	40	60	80	57	42	58
kg/ha	22500	181	103	64	136	208	128	63	114
	45000	350	264	140	271	346	181	103	173

The application of 5 g of sodium selenite or 5625 kg fly ash per ha can make Se contents in wheat grains be up to the level in the non-disease affected zone in the Guanzhong Plain Shaanxi Province. Also, Se contents in two types of soils were compared. Se contents in Red soil together with growing wheat plants and wheat grains are higher than in Bicolour soil.

Se contents in wheat plants in their different growth stages are in a decreasing order as follows: wheat seedling, heading wheat plants, matured wheat plants, wheat grains (Table 3). It is found from Table 2 that Se contents in soils have less change around wheat harvast. This indicates that the decrease of Se contents in wheat plants with becoming mature is not because of Se content decrease in soils but physiological behaviours of wheat plants in Se intakes.

The pot experiment (Table 4) shows that the wheat grain weight from the Red soil and Bicolour soil with sodium selenite application are 10.2–26.4% and 32.4–40.5% higher than those from control respectively, and those with fly ash are 26.8–40.3% and 21.4–50.2% respectively. The percentage of yield increase in the treatments added fly ash was higher than added sodium selenite that may be led by other factors except Se. In recent years, some workers have suggested that spraying Se solution over crop leaf can increase wheat yields (Grant, 1965). This is a significant result, for there has been no evidence to show that Se is an essential element for plant. So it is necessary to carry out further study on the function of Se to increase the wheat yield.

Field experiments started in the fall of 1983 in Shan soil with Se fertilizer applied. Winter wheat was grown for three years in succession, and Se contents in wheat grains were determined. It can be seen from the results in Fig.1 that under the field conditions, 225 g of sodium selenite or 45000 kg of fly ash per ha added can further prove that Se contents in wheat grains of the third year are still 50–30 ppb, being higher than those in the non-disease affected area in the Guanzhong Plain of Shaanxi Province, apart from the similar experimental results obtained in pot experiment (Gupta, 1975).

Table 4 Effect of soil with Se applied upon wheat yields

Experimental treatments		Mixed Loess & Red earth with Concretions		Loess-clad Red Colloid Earth	
		Wheat grains weight, g/pot	Increase over control, %	Wheat grains weight, g/pot	Increase over control, %
Control experiment		$\frac{4.62 \pm 0.552^{*}}{2}$		$\frac{4.2 \pm 0.679}{2}$	
Sodium	75	$\frac{5.09 \pm 1.980}{2}$	10.2	$\frac{5.56 \pm 0.040}{2}$	32.4
selenite	150	$\frac{5.84 \pm 0.042}{2}$	26.4	$\frac{5.90 \pm 0.040}{2}$	40.5
applied, g/ha	225	$\frac{5.39 \pm 0.263}{2}$	16.7	$\frac{5.84 \pm 0.98}{2}$	39.0
Fly ash	5625	$\frac{5.86 \pm 0.263}{2}$	26.8	$\frac{5.19 \pm 0.014}{2}$	23.6
applied	11250	$\frac{5.57 \pm 0.163}{2}$	20.6	$\frac{6.09 \pm 0.092}{2}$	45.0
kg/ha	22500	$\frac{5.81 \pm 0.099}{2}$	25.8	$\frac{6.31 \pm 0.106}{2}$	50.2
	45000	$\frac{6.48 \pm 0.495}{2}$	40.3	$\frac{5.10 \pm 0.453}{2}$	21.4
mean			23.8		36.0

Note:* $\frac{\text{Average number} \pm \text{Standard deviation}}{\text{Number of Sample}}$

CONCLUSIONS

In Kaschin-Beck disease zone with low Se soils spreading on the Weibei Highland in Shaanxi Province, addition of an extremely small amount of sodium selenite (75 g/ha) or fly ash (5625 kg/ha) to several major types of soils can improve available Se contents in soils and make Se contents in wheat increase from 10 ppb to over 30 ppb, reaching the level of Se contents in wheat in the non-disease affected zones in the Guanzhong Plain. In the field experiments 225 g of sodium selenite or 45000 kg of fly ash per ha added to Shan soil can make Se contents in wheat grain in the third year still be 50–30 ppb, being higher than that in the non-disease affected area in the Guanzhong Plain, Shaanxi Province. At the same time, there is a positive correlation between Se contents in wheat grains and amount of Se applied. Owing to large amount of application of fly ash and inconvenience of transportation, it is better to apply sodium selenite apart from the fact that fly ash can be used locally.

As for the availability of the added Se in two types of soils for the experiments, the available Se is lower in Bicolour soil than in Red soil. This may be mainly related to the fact that there is a low total Se in the Bicolour soil, $CaCO_3$ is at high level and organic matter contents are lower, so that the Se in Bicolour soil is easily fixed by $CaCO_3$ as insoluble form. Other factors that affect availability of Se need to be further studied.

It is clear that Se added to soil can increase wheat grain yield. Although some workers have made more studies of Se in plants, so far it has not yet been clear what is the physiological effect of Se upon plants so that the necessity of Se nutrition for plants has not yet been concluded (Gupta, 1975). The yield increase effects of Se upon winter wheat found in this research are worth to further studying.

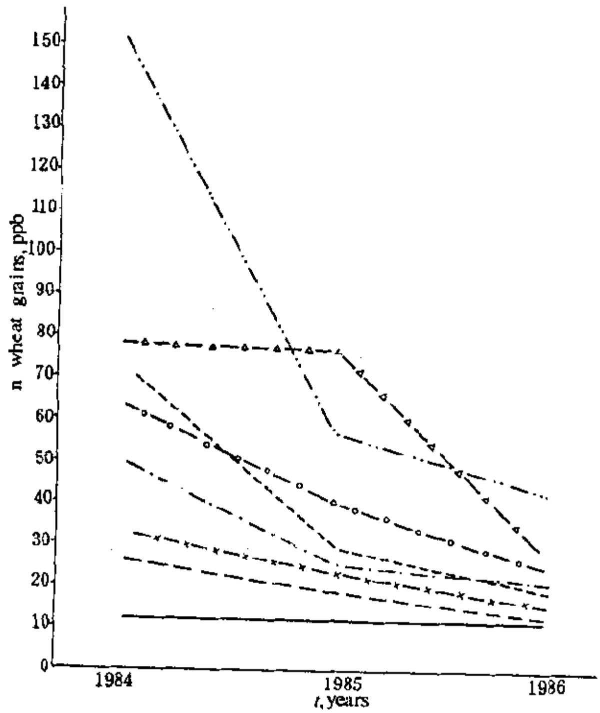

Fig. 1 Se contents in wheat grains (ppb) in soils with Se added in farmlands in different years

——control experiment

—· —· —· —· 75g of sodium selenite/ha

- - - - - 150 g of sodium selenite/ha

— · · — · · — · · 225 g of sodium selenite/ha

– – – 5625 kg of Fly ash/ha

-x-x- 11250 kg of Fly ash/ha

-o-o- 22500 kg of Fly ash/ha

-Δ-Δ- 45000 kg of Fly ash/ha

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