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Capacity and degree of iodine absorbed and enriched by vegetable from soil

WENG Huan-xin[1], WENG Jing-ke[2], YONG Wen-bin[1], SUN Xiang-wu[1], ZHONG Hang[3]

(1. Institute of Environment & Biogeochemistry, Zhejiang University, Hangzhou 310027, China, E-mail: gswenghx@public.zju.edu.cn; 2. Department of Biology, Zhejiang University, Hangzhou 310027, China; 3. Soil & Fertilizer Station of Zhejiang Province, Hangzhou 310004, China)

Abstract: To understand the biogeochemical transfer of iodine, the absorbability and bioaccumulation of iodine in tested vegetables(radish, spinach and Chinese cabbage) are examined by applying iodic fertilizer composed of kelp and diatomaceous earth. The experimental results show that when iodine in soil is not excessive, the concentrations of iodine in tested vegetables increase as the content of iodine in soil increases. The absorbability and enrichment degree of iodine in various vegetables and in various parts of the same vegetable are different, which explains that the concentration of iodine in plant is determined by the plant type and the physiological action of plant. The patience order of tested vegetables to excessive iodine is Chinese cabbage > spinach > radish. These results have theoretical and practical significance in opening up a new way for ameliorating poor iodine environment with artificial means.

Keywords: iodine; biogeochemical transfer; absorbability; vegetable; IDD

Introduction

Iodine is a key element composing thyroxin, which plays an important role in the growth of the human body. Thyroxin promotes protein synthesis, regulates energy conversion, preserves the composition of central nervous system, and maintains normal metabolism. Therefore, once the human body is short of iodine, it can lead to physiological malfunction and bring about Iodine Deficiency Disorder(IDD)(Li, 1985; Yu, 1983).

The human body needs 100—150 μg iodine every day, about 75%—80% of which comes from vegetable foods(Liao, 1992; Wang, 1985). The concentration of iodine in vegetables is determined by two facts. One is background content of iodine in soil, and the other one is biological assimilation. The background content of iodine in soil bears a relation to the parent material, texture, and geographic distribution of soil. Because of precipitation eluviation, the content of iodine in soil is relative lower in interior and mountainous area, which results in the deficiency of iodine in vegetables, and the prevalence of IDD(Zhu, 1989). Iodine in animals bodies comes mainly from forage crop. Iodine deficiency in forage crop is caused by iodine deficiency in soil, which brings about IDD of animal(Zhang, 1995). We know but a little about the plant absorption of iodine from soil and its bioaccumulation. It has been made clear by research that the growth of higher plants was stimulated by spraying suitable quantity of potassium iodate and potassium iodide. However, some important questions are unanswered by research, such as the quantitative relationship between soil iodine and vegetable iodine, and the enrichment degree of iodine in different vegetables.

In this paper, the relationship of iodine between soil and plant was researched and analyzed quantitatively. By applying iodic fertilizer, we examined how the plant absorbs and bioaccumulates iodine from soil. This not only has important theoretical significance in revealing biogeochemical transferable behaviors of iodine, but also has practical significance in improving poor-iodine environment.

1 Materials and experiments

1.1 Preparation of iodic fertilizer

The iodic fertilizer used in this study was composed of kelp and diatomaceous earth. The accumulative

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concentration of iodine in dry kelp is around 2‰—3‰, most of which can dissolve in water (Hou, 1998). The diatomaceous earth is made up of diatomaceous remains and clay minerals. Because of its strong absorbent capacity, the diatomaceous earth can prevent volatilization of iodine and preserve the moisture of soil.

The fresh kelp was dried under 40℃ and then was forced through a 15-hole sieve. The diatomaceous earth collected from Shenzhou was through a 100-hole sieve. The grain kelp and diatomaceous earth were mixed fully in the ratio of 1:1, and then was made into granular, of which the concentration of iodine was measured.

1.2 Culture of vegetables

The soil used in the experiment was collected from a local flower nursery. The background content of iodine in soil was measured by the method from Wei(Wei, 1992). The soil was put into flowerpots where the radish, spinach and Chinese cabbage were cultures on the basis of plantation requirement. Vegetables were grown out of door and watered with running water which contained iodine below 4 μg/kg. The iodic fertilizer was used as base manure with various ratios. Every test was done by 3 times.

1.3 Samples and analysis

The maturation period of radish is about 90 days. Collect the leaf blades and the rhizome of radish respectively after 60 and 90 days. The maturation period of spinach and Chinese cabbage is about 45 days. Collect them after 45 days. Dry the collected samples under 40℃ and then pulverize them into powder.

The concentrations of iodine in these samples were analyzed by the ferric thiocyanate-nitric acid catalytic kinetic method (GB/T 13882-92).

2 Results and discussion

2.1 Absorbing capacity of the tested vegetables to iodine

The concentration of iodine in radish increases as the content of iodine in soil increase. Fig. 1 illustrate that there is a positive correlation between iodine in radish and iodine in soil, when the content of iodine added in soil is below 130 mg/kg. When the content of iodine added in soil is more than 150 mg/kg, the concentration of iodine in radish stops increasing as the iodine in soil increases. This suggests that there is a restrictive concentration in radish absorbing iodine from soil. If the restrictive concentration is considered as the absorbing capacity of vegetable to iodine, the absorbing capacities of rhizome and leaf blade and of radish are respectively 24.57 mg/kg and 37.88 mg/kg. It shows that the absorbing capacities of iodine in different parts of the same vegetable are various. The channel of iodine entering from soil vegetable body is "root hair→rhizome→leaf blade". The concentration of iodine in leaf blade is higher than that in rhizome, which indicates that the distribution of iodine in vegetable body has relation to physiological action of vegetable, rather than determined by the transferring channel of iodine. Leaf blade is the main body of photosynthesis, which needs a great quantity of moisture and mineral matters. In the process of iodine transferring from soil to root with moisture and mineral matter, the rhizome is only a tunnel and the leaf blade is the destination, which may result in more iodine accumulated in leaf blade.

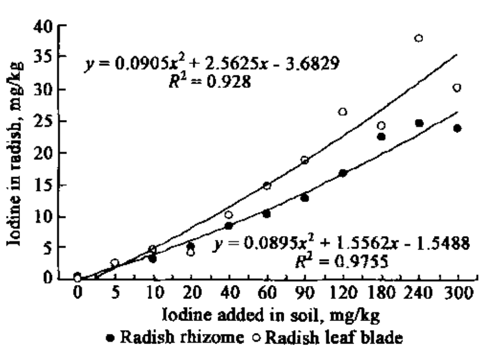

Fig. 1 Relationship between iodine in radish iodine added in soil

The concentrations of iodine in spinach and Chinese cabbage increase as the content of iodine in soil increase. The absorbing capacities of iodine in spinach and Chinese cabbage are respectively 71.67 mg/kg and 49.99 mg/kg

(Fig.2), which are obviously higher than that in radish. Although the growth period of spinach and Chinese cabbage is merely half of the radish's, the concentration of iodine is higher than that in radish. This indicates that the absorbing quantity of iodine in plants bears a relation to plant types. Spinach and Chinese cabbage are leaf blade and plants, in which iodine from soil is directly transferred to leaf blade and enriched there. Therefore, the fact that iodine distributes mainly in leaf blade explains that the physiological action of plant plays an important role in absorbing capacity of iodine.

2.2 Enrichement degree of iodine in lants

The enrichment coefficient (R) is used as to evaluate the enrichment degree of iodine in plants: $R = C_1/C_2$, in which C_1 is the concentration of iodine in plant, and C_2 is the concentration of iodine in soil.

Fig. 3 and Fig. 4 illustrate the enrichment coefficients of tested vegetables change with content of iodine added in soil. Under the background content of iodine in natural soil (0.6 mg/kg), the enrichment coefficients of iodine in radish rhizome, spinach and China cabbage are more than 1, which indicates that plants have strong enrichment action to iodine from soil.

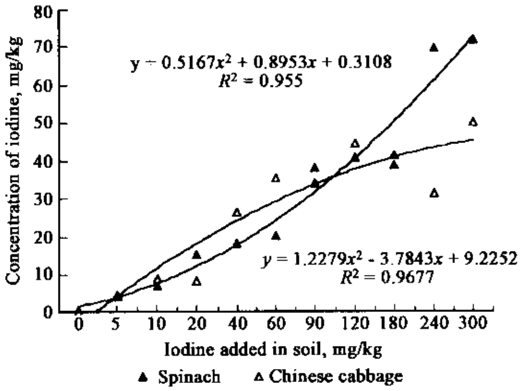

Fig. 2 Relationship between iodine in spinach, Chinese cabbage and iodine added in soil

It may be seen from Fig.3 that when the content of iodine in soil is natural background, the enrichment coefficient of iodine in leaf blade is lower than that in rhizome. This indicates when the content of iodine in soil is quite low, only a little iodine was transferred to the leaf blade because some iodine is intercepted and captured by rhizome in the process of biotransfer. As the content of iodine in soil increases, the enrichment degree of iodine in radish rhizome begins to reduce, and that in radish leaf blade begins to increase. When the content of iodine added in soil is above 50 mg/kg, the enrichment coefficients both in radish rhizome and leaf blade reduce gradually. The enrichment degree of iodine in leaf blade is higher than that in rhizome except for under background content of iodine in soil, which exhibits the difference in enrichment degree of iodine in various parts of the same plant.

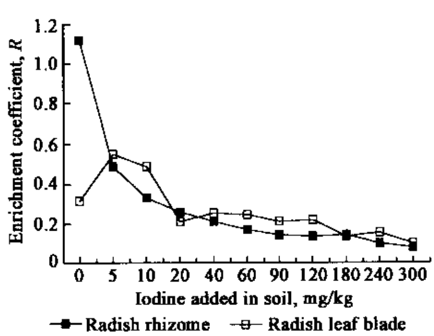

Fig.3 Enrichement coefficients of iodine in radish change with iodine added in soil

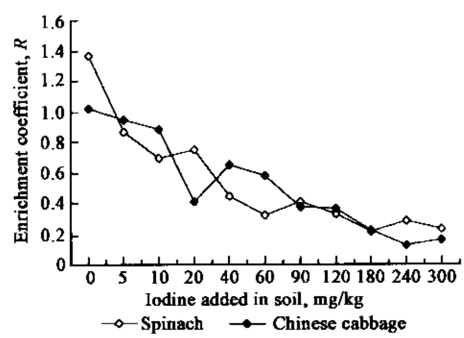

Fig. 4 Enrichement coefficients of iodine in spinach and Chinese cabage change with iodine addd in soil

The enrichment coefficients of iodine in spinach and Chinese cabbage decrease as the content of iodine in soil increases. The enrichment coefficients of iodine in spinach and Chinese cabbage are approximately similar but are higher than that in radish (Fig.3, Fig.4), which indicates that there is difference in enrichment degree of iodine in different plants.

2.3 Patient concentration of iodine in plant

It has been tested that excessive iodine is poisonous to plants and the human body (Suzuki, 1965; Qian, 1986). Different plants express different sensitivities to excessive iodine (Liao, 1992). According to the experiment, the seedlings of plants were badly injured when the content of iodine in soil is relatively high. In details, when the content of iodine added in soil is 120 mg/kg, a few roots of radish seedling rotted away. When the content of iodine added in soil is above180 mg/kg, most of the radish seedling roots rotted away and died, while there is no abnormal phenomena in the mature seedling. Under the same condition, some of the spinach seedling roots rotted away and Chinese cabbage expressed dysphasia and body undersized.

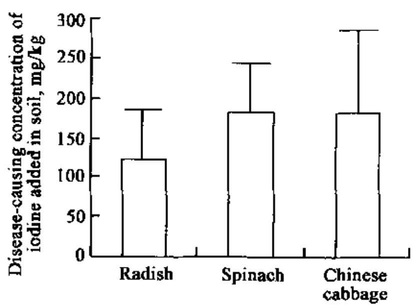

Fig.5 Disease-causing concentration of iodine in tested vegetables

The aforesaid phenomena show that the seedling of the plants is more sensitive to excessive iodine compared with mature seedling. It is due to the physiological maturity of plant enhancing the mithridatism to excessive iodine. There are differences in patience of three tested vegetables to excessive iodine. The order of their patience to excessive iodine is Chinese cabbage > spinach > radish (Fig.5). However, the order is not fully consistent with their capacity of absorbing iodine.

3 Summarization

The concentration of iodine in radish increases as the content of iodine in soil increases, when the content of iodine added in soil is below 130 mg/kg. When iodine added in soil is above 150 mg/kg, the concentration of iodine in radish did not vary as iodine in soil. This suggests that the plant absorbing iodine from soil is limited by absorbing capacity. The concentration of iodine in radish leaf blade is higher than that in radish rhizome. On the one hand it may has relation to leaf blade being the transport termination in the transfer process of iodine from soil to plant body with moisture and mineral matter, and on the other hand it my be due to the physiologic action of plant. Spinach and Chinese cabbage are leaf blade vegetable, in which iodine has a positive correlation with the concentration of iodine added in soil. Their absorbing capacities are obviously higher than the radish's.

Under the background content of iodine in soil, the enrichment coefficients of iodine in tested vegetables are more than 1, which exhibits that plants have the stronger absorbability and enriching action to iodine from soil. As the iodine in soil increases, the enrichment coefficients of iodine in tested vegetables gradually reduce. The enrichment coefficients of iodine in tested vegetables and in leaf blade and rhizome of radish are different, which indicates that there is difference in enrichment degree of iodine in various plants and in various parts of the same plant.

According to the experiment about disease-causing concentration of iodine, it is also made clear that the patience order of tested vegetables to excessive iodine is Chinese cabbage > spinach > radish.

The iodic fertilizer made of kelp and diatomaceous earth can be used as a supplement of iodine to soil. The iodine can be dissolved out from kelp and absorbed by tested vegetables. If it is applied in the areas where iodine is deficient, the concentrations in the plants will be heightened and the environment of iodine deficiency will be improved, which will furnish theoretical and practical bases to open up a new way for ameliorating poor iodine environment by artificial means.

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