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Effects of Selenate Ion Concentration in Nutrient Solution on the Growth and Essential Oil Content of Wormwood(Artemisia absinthium L.)[1)]

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배양액 내의 Selenate 이온농도가 웜우드(*Artemisia absinthium* L.)의 생육 및 정유함량에 미치는 영향[1)]

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Abstract

This study was conducted to evaluate appropriate selenate ion concentration for the production of high functional vegetables. Sodium selenate was treated 0, 2, 4, 6 and 8㎎/ℓ using herb nutrient solution developed by European R & D Vegetable Center in Belgium.

Low level of Na_2SeO_4 concentration increased the growth of wormwood, but high selenate concentration decreased the growth. Total chlorophyll content was increased by sodium selenate. The higher selenate ion concentration in the nutrient solution, the more total chlorophyll content was. The vitamin C content in wormwood was high at 2 and 4㎎/ℓ treatment, showing good growth, at higher concentration, however, the vitamin C content decreased. At 4㎎/ℓ selenate ion concentration, essential oil content of wormwood was best. But higher selenate ion concentration decreased essential oil content. The uptake of Se by the plant increased with the increase of selenate ion concentration.

주 제 어 : 수경재배, selenate ion, 영양, 정유, 웜우드
Key words : hydroponics, selenate ion, nutrition, essential oil, wormwood

Introduction

Wormwood (*Artemisia absinthium* L.) is a member of Compositae family. The plant is a shrubby, perennial herb and indigenous to North America, Southern Europe, Northern Africa and Northern Asia. Foliage is silver-gray. And the herbage or its juices is used for various types of cancers and indurations of the breast, foot, larynx, liver, spleen,

1) 본 실험은 농림수산부 시행 농림수산특정연구사업의 일부로 수행된 것임.

stomach, testicles, tongue, and uterus.

Essential oil is mainly used in the preparation of Wermutwein for its bitter tonic flavor. And it is also used for not only fragrance components in creams, detergents, lotions, perfumes and soap, but also medicinal and veterinary liniments. The essential oil of wormwood contains thujone, caryophyllene, phellandrene, pinene, thujyl alcohol, thujyl acetate, thujyl isovalerate, thujyl palmitate, camphene, cadinene and nerol.

Selenium is required in animal nutrition, though it is not classified as an essential plant nutrient(Mayland et al., 1991). It has been reported that selenium works as an antioxidant in relation to glutathion peroxidase activity. Besides it was suggested that the ingestion of vegetables with selenium can be more useful than directly taking tablet of selenium.

The objective of this study was to evaluate the effect of selenate ion on the growth and quality of wormwood and to investigate optimal selenate ion concentration in nutrient solution.

Materials and Methods

This study was carried out in the glasshouse of Korea University. The tested plants was wormwood (*Artemisia absinthium* L.). The culture method used in the experiment was a deep flow culture(DFC) system. The plants were grown by using a nutrient solution developed for herb plants by European Vegetable R & D Center in Belgium. The composition of the nutrient solution was shown at table 1. The nutrient solution was circulated by a pump with 24h−timer in 15 min per hour intervals. The nutrient solution was replaced with fresh solution every 15th day in early growth stage and every 10th day in later growth stage.

Wormwood was sown in plug−cell filled with commercial substrates for horticultural crops (Supermix, Nong Kyung Co.) on April 20 in 1997. Seedlings were thinned to one plant per cells at 3 weeks after sowing. At the third leaf stage, seedlings were transplanted into water for 3 days. For the hardening of the plants, they were grown in half−strength nutrient solution for 5 days and then planted to the bed filled with nutrient solution developed for herb plants. 5 days later the plants were treated with Na_2SeO_4 0, 2, 4, 6 and 8㎎/ℓ. Electric conductivity was adjusted to 2.4±0.25mS/㎝, and pH to 6.3±0.25. The plants were harvested at 20 days after treatment.

Table 1. The composition of the nutrient solution for herb plants developed by European Vegetable R & D Center in Belgium.

Macro nutrient	mmol/L	Micro nutrient	㎛ol/L
NO_3−N	18.0	B	26.5
K	11.0	Fe	100.0
H_2PO_4−P	2.0	Cu	0.4
Ca	4.5	Zn	3.7
Mg	1.0	Mn	5.0
S	1.0	Mo	0.5

To investigate apparent growth, plant height, leaf length, leaf width, root length and fresh weight (top & root) were measured. Dry matter rate was also measured. The content of essential oil was analyzed by steam distillation method by Letchamo(1992) and chlorophyll content was measured by

DMF methods of William and Paul. (1985) The selenate content was determined by fluorometric method of Whetter and Ullrey (1978) and vitamin C content was determined by 2,6−dichloro phenolindophenol method by fluorometer. (Joo et al., 1991)

The statistical analysis of data was obtained by the Duncan's multiple range tests of SAS program.

Results and Discussion

The growth of wormwood was good at 2 and 4㎎/ℓ Na_2SeO_4 treatment (Table 2). But high selenate ion concentration in nutrient solution resulted in the decrease of the plant. That is, low concentration of selenate promoted the plant growth, high selenate ion concentration, however, reduced the plant growth. These results are in general agreement with those obtained by other researchers in experiment of alfalfa and clover (Broyer et al., 1966). With increased Se application, growth and yield of alfalfa (Medicago sativa L. var. African) and subterranean clover (*Trifolium subterraneum* L.) decreased.

Low level of selenate concentration resulted in the increase of dry matter (Table 3). This result was not in consistent with that of Biacs et al. (1995). They suggested that dry matter yield decreased by Se treatment.

Fresh weight increased at low selenate ion concentration in nutrient solution. The highest fresh weight was obtained a 8㎎/ℓ Na_2SeO_4 treatment (Table 3). It is thought that low Se concentration increased chlorophyll content and this promoted photophosphorylation rate, resulting increased growth and fresh weight of wormwood.

Table 2. The effects of selenate concentration on the growth of wormwood (*Artemisia absinthium* L.).

Na_2SeO_4 (㎎/ℓ)	Top length (cm)	Leaf length (cm)	Leaf width (cm)	Number of leaf	Root length (cm)
0	34.2ab[z]	16.9ab	17.3ab	9.0a	54.7a
2	36.1ab	18.7a	21.8a	10.0a	44.3a
4	35.6ab	16.7b	18.7ab	11.7a	54.5a
6	30.6b	14.3c	16.1b	12.0a	48.3a
8	38.8a	15.9bc	17.4ab	6.7a	

[z]Means separation within columns by Duncan's multiple range test, at 5% level.

Table 3. The changes of wormwood (*Artemisia absinthium* L.) weight by selenate treatment.

Na_2SeO_4 (㎎/ℓ)	Fresh weight g		Dry weight ratio (%)		T/R ratio
	Top	Root	Top	Root	
0	17.0b[z]	9.0ab	13.5c	9.1a	1.88a
2	29.6a	15.0a	18.4a	10.2a	1.97a
4	24.2ab	14.7a	15.3b	10.0a	1.64a
6	22.2ab	12.2ab	14.5bc	10.4a	1.81a
8	16.2b	7.7b	14.9b	10.3a	2.10a

[z]See Table 2.

The total chlorophyll content increased with Se treatment. Though the content decreased a little in 4㎎/ℓ treatment, total chlorophyll content increased gradually with Se concentration (Fig. 1). Peng et al.(1992) reported that selenate and superoxide dismutase protected the cells from injury by semiquinone radicals and reduced lipid peroxidation and Se deficiency resulted in lower glutathion peroxide activities and higher levels of lipid peroxidation. Also, exogenous application of active reducing agents

such as glutathion significantly inhibited chlorophyll degradation of detached parsley leaves to an extent related to their in vitro effectiveness of reducing activity (Meir et al., 1995). That is, high Se concentration in nutrient solution might cause increase of glutathion peroxidase activity and reducing activity. Due to this activated reducing power stimulated a kind of pigment — chlorophyll formation. In addition, it was suggested that amending the soil with Se and Zn stimulated increase of alpha−carotene and lutein synthesis and the decrease of beta −carotene with a slight increase in the total carotenoid content (Biacs et al., 1995).

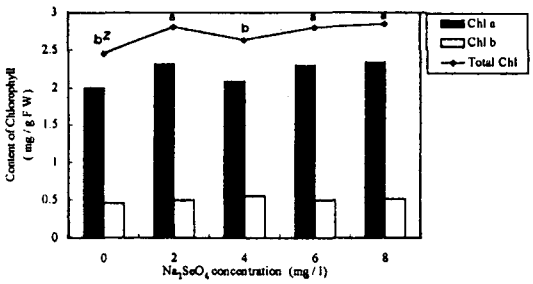

Fig. 1. The effect of Na_2SeO_4 concentration on the contents of chlorophyll in *Artemisia absinthium* L.
[z]See Table 2.

The vitamin C content increased in selenate 4mg/ℓ treatment, which showed good growth, but decreased in selenate 6 and 8mg /ℓ (Fig. 2). Low Se concentration in the the nutrient solution increased the content of vitamin C. It is regarded that proper Se concentration resulted in the increasing of glutathion synthesis as a protecting mechanism.

The essential oil content was the highsest in 4mg/ℓ Na_2SeO_4 treatment but high selenate concentration reduced the essential oil conten (Fig. 3). It is suggested that the decrease of growth, however, more detailed study is required.

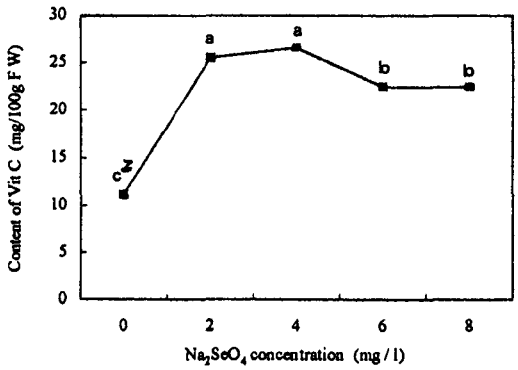

Fig. 2. The effect of Na_2SeO_4 concentration on the vitamin C content in *Artemisia absinthium* L.
[z]See Table 2.

Selenium uptake by wormwood responded significantly to the selenate concentration in the nutrient solution. Plants absorbed selenium from the nutrient solution in proportion to the concentration of selenate. The higher the selenate concentraion, the more Se uptake (Fig. 4). Selenate ions were absorbed and transported in to plant xylem sap but the selenium was more rapidly metabolized to organoselenium compounds and transported into upper portions of the plant (Mayland et al., 1991). Plant absorbed Se according to the concentration, availability and plant development and species (Trelease and Beath, 1949).

Wormwood showed more tolerance to selenate ion concentration. Mugwort in same *Artemisia* genus showed marked decrease at high selenate ion concentration(Lee and

Park, 1997). Whereas growth of wormwood slightly reduced. Our results implied that the strong tolerance to selenate in wormwood caused to be resulted in, because wormwood would be less absorbed selenium by protecting mechanism.

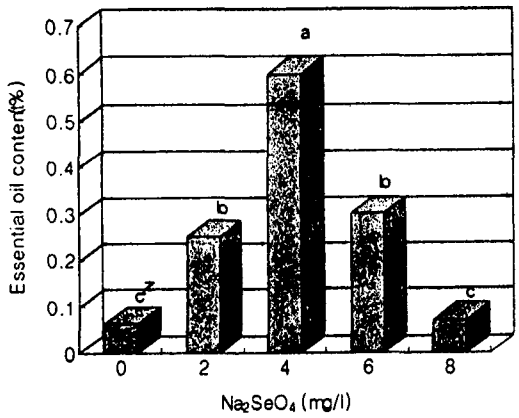

Fig. 3. The effect of Na_2SeO_4 concentration on the content of essential oil in *Artemisia absinthium* L.
[z]See Table 2.

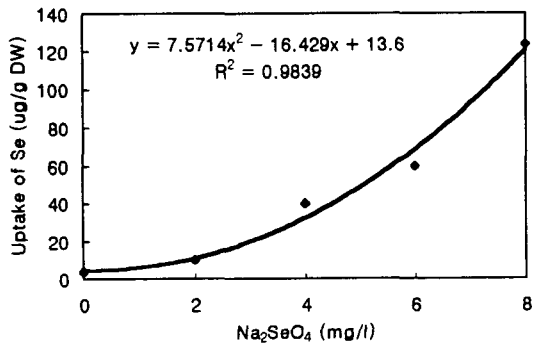

Fig. 4. The effect of Na_2SeO_4 concentration on the Se uptake in *Artemisia absinthium* L.

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摘 要

본 실험은 고기능성 채소 생산을 위한 배양액내의 적정 셀레니움 농도를 구명하고자 수행되었다. 벨기에의 채소연구소에서 허브재배를 위해 개발된 양액을 이용하여 각각 Na_2SeO_4를 0, 2, 4, 6, 8mg/ℓ농도로 처리하였다. 배양액내 셀레니움의 농도가 국화과 식물인 향쑥의 생육에 미치는 영향을 알아본 결과 저농도의 처리는 생육을 향상시켰으나 6mg/ℓ 이상의 고농도 처리는 생육을 감소시켰다.

엽록소의 함량은 셀레니움 처리에 의해 증가되었는데 배양액 내의 selenate ion 농도가 높을수록 전체 엽록소함량도 증가 되었다.

비타민 C의 함량은 좋은 생장을 보였던 4mg/ℓ처리까지는 증가하였으나 그 이상으로 농도가 증가했을 때 비타민C의 함량은 감소하였다.

저농도의 selenate 이온 농도는 정유의 함량을 증가시켰으나 고농도에서는 정유의 함량이 감소되었다.

식물에 의한 셀레니움의 흡수는 배양액 내의 selenate 이온 농도가 증가할수록 촉진되었다.