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Effects of Sulfate Ion Concentration in Nutrient Solution on the Growth and Quality of *Artemisia mongolica* var. *tenuifolia*

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배양액 내의 황산이온 농도가 참쑥의 생육과 품질에 미치는 영향 [1)]

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Abstract

This experiment was conducted to evaluate the effects of sulfate ion concentration in nutrient solution on the growth and quality of Mongolian wormwood (*Artemisia mongolica* var. *tenuifolia*). Sulfate ion concentration was treated 0, 0.5, 1, 2 and 3mM using the modified nutrient solution composition for herb plants developed by European Vegetable R & D Center in Belgium.

The growth of Mongolian wormwood was good at 3mM treatment and dry weight was best at 3mM treatment. Chlorophyll content increased with sulfate ion concentration. Mineral content did not show any significant difference among treatments. But Ca content in tissue markedly decreased at 3mM treatment. Sulfate ion uptake increased in proportion to sulfate ion concentration in nutreint solution; the higher sulfate ion concentration, the more uptake of sulfate ion by plant. At 1mM sulfate ion treatment, essential oil content was best, but the higher sulfate ion concentration resulted in decrease of essential oil content.

Key words : hydroponics, sulfate ion, nutrition, essential oil, *Artemisia*

[1)] 본 실험은 농림수산부 시행 농림수산특정연구사업의 일부로 수행된 것임.

Introduction

Mongolian wormwood(*Artemisia mongolica* var. *tenuifolia*) is a member of the Compositae family and an annual herbaceous plant that grows in wild forms. It has strong woody stems and grows to 2m tall. The inflorescence color is light red. Young shoot can be used for biomedicine- as a styptic and anodyne, and for a popular remedy for gynecopathy, gastroenteric disorder, neuralgia and constipation-, as well as for flavoring rice cakes. The main constituents of essential oil are cineole, camphor, thujone, caryophyllene, borneol, coumarin and linalool. The essential oil from this plant is very useful. It is used for biomedicine, as well as for a fragrance component in creams, detergents, lotions, perfumes, soaps and condiments.

For cultivation of herbs, the enhancement of essential oil content is required. Many researches has been accomplished for this purpose, but, no marked effect has been shown in fertilizer and content of essential oil. Therefore, the objective of this study was to evaluate the effect of sulfate ion in nutrient solution on the growth of *A. mongolica* var. *tenuifolia* and to investigate effect of sulfate ion on the qualities such as essential oil, chlorophyll and mineral content.

Materials and Methods

This study was carried out in the glasshouse of Korea University. Mongolian wormwood(*A. mongolica* var. *tenuifolia*) was propagated by cutting of sucker. The uniform seedlings were transplanted into water for 3days and thereafter grown for hardening in half-strength nutrient solution for 5 days. And then they were planted to bed in DFC system and treated with 0, 0.5, 1, 2 and 3mM of SO_4^{2-}, respectively. Modified nutrient solution for herb plants was applied, which developed by European Vegetable R & D Center in Belgium(Table 1). The nutrient solution was circulated by a pump with 24h-timer in interval 15min per hour. The nutrient solution was replaced with fresh solution every 15 day in early growth stage(4-5th leaf expanded) and every 10 days in later growth stage(more than 6th leaf expanded). Electric conductivities were adjusted to 2.2±0.25, 2.95±0.25, 3.0±0.25, 2.95±0.25 and 3.3±0.25 mS/㎝, and pH was adjusted to 6.6± 0.2, 6.5±0.2, 6.3±0.2, 6.5±0.2 and 6.0 ±0.2, respectively. They were harvested on 20 Jul. 1997.

Plant height, leaf length, leaf width, root length and fresh weight(top & root) were investigated and dry matter ratio was also measured. The essential oil content was analyzed by steam distillation method by Letchamo(1992). The content of Ca, Mg, and K was determined by atomic absorption spectrophotometer(Model 3208 HPSF AAS, Hewlett Packard), which were calculated by unit of mg per g dry weight. Nitrate content was analyzed

by spectrophotometric method (Cataldo, 1975) and chlorophyll content was analyzed by DMF extraction methods of William and Paul(1985). The content of sulfate ion was measured by slightly modified method of the Commitee of Culture Analysis Method(1983).

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

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

Macro nutrient	mM	Micro nutrient	μM
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

Results and Discussion

Sulfate ion treatment had significant effects on plant growth in Mongolian wormwood (Table 2). 3mM of SO_4^{2-} treatment showed the best results in overall growth of plants. Shoot dry weight was best at 3mM of SO_4^{2-} treatment as compared with other treatments. This result had agreement with that of Lopez et al.(1996) with tomato. They reported that at sulfur-dificient treatment, shoot dry weight of plants was significantly low. Cerda et al.(1984) and Martinez et al.(1984) reported that tomato plants grown in high concentrations of sulfates had thinner stems and smaller, dark-green leaves. And they suggested that these symptoms appeared on the youngest leaves and more severe with plant age and sulfate concentration. Contrary to other species such as rice(Osiname and Kang, 1975), corn(Rehn and Caldwell, 1970) and sugar cane(Fox, 1976), Mongolian wormwood might be able to tolerate high concentrations of sulfate.

Table 2. The effects of SO_4^{2-} concentration on the growth of *Artemisia mongolica* var. *tenuifolia*.

SO_4^{2-} (mM)	Top length (cm)	Leaf length (cm)	Leaf width (cm)	Number of leaf	Root length (cm)
0	33.5c[z]	12.0b	5.8d	28.0b	30.9c
0.5	37.1b	12.5b	8.1c	37.0ab	33.7c
1	42.3a	18.9a	9.5bc	31.0ab	32.4c
2	37.8b	12.2b	10.9b	40.7a	37.8b
3	42.6a	13.2b	12.2a	34.7ab	42.6a

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

Table 3. The change of weight of *Artemisia mongolica* var. *tenuifolia.* by sulfate ion concentration treatment.

SO_4^{2-} (mM)	Fresh weight (g)		Dry weight ratio (%)		T/R ratio
	Top	Root	Top	Root	
0	19.5b[z]	4.6c	11.5c	4.5e	4.24a
0.5	39.0a	8.3bc	13.2b	5.1d	4.70a
1	27.7ab	9.9b	12.0c	7.3c	2.80b
2	29.3ab	10.8ab	11.8c	9.1b	2.71b
3	36.1a	14.4a	14.3a	12.5a	2.51b

[z] See Table 2.

A lack of sulfate ion reduced chlorophyll content. The higher sulfate ion in nutrient solution, the greater content of chlorophyll(Fig. 1). This result was corresponded with Passera and Ghisi(1982). Also Lopez et al.(1996) reported that the chlorophyll a/b ratio was inversely proportional to the sulphate concentration in tomato.

The mineral content of plant tissue by sulfate ion concentration was shown at table 3. The mineral content of A. mongolica var. *tenuifolia* was not shown any significant difference. However, Ca content was lowest at 3mM treatment. Lopez et al.(1996) showed an antagonism between the calcium and sulfate ions in tomatos. Martinez et al.(1984) observed that the Ca content in leaves decreased with an increase in the sulfate concentrations of the nutrient solution. Mg, N, and K content in leaves did not show any significant difference among treatments.

The uptake of sulfate ion by plant increased with increase of sulfate ion concentration(Fig. 2). Sulfur is actively absorbed by plants, mainly as SO_4^{2-}, and assimilated into cystein(Ketter et al., 1991). At 3mM treatment, the active growth was accomplished, therefore the

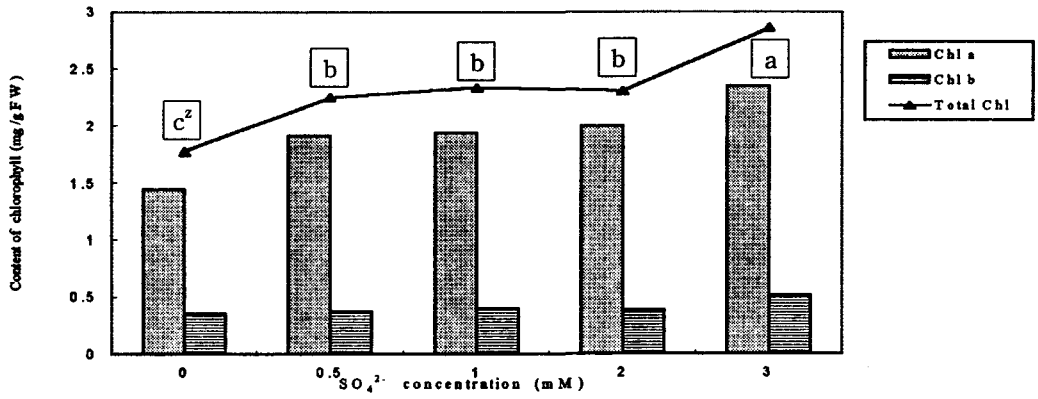

Fig. 1. The effect of SO_4^{2-} concentration on the contents of chlorophyll in *Artemisia mongolica* var. *tenuifolia*..

[z] See Table 2.

Table 4. The effects of SO_4^{2-} concentration in nutrient solution on the mineral contents of *Artemisia mongolica* var. *tenuifolia*.

SO_4^{2-} (mM)	K (mg/g DW)	Ca (mg/g DW)	Mg (mg/g DW)	NO_3^- (mg/g DW)
0	966.5ab[z]	87.0a	47.0a	4433.0a
0.5	964.8ab	87.3a	47.2a	4477.8a
1	1044.0a	89.2a	48.2a	4584.9a
2	1000.8a	88.3a	45.0a	4408.9a
3	1031.2a	58.1b	44.2a	4730.3a

[z] See Table 2.

respiration might increase. Increased ATP, due to increase of repiration, improved active transport, as a result, uptake of sulfate ion might markedly increase at 3mM treatment.

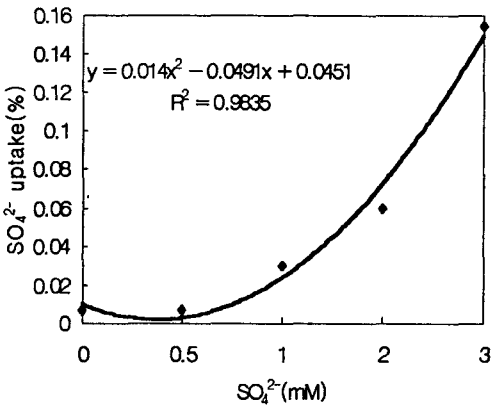

Fig. 2. The effect of SO_4^{2-} concentration on the uptake of SO_4^{2-} in *Artemisia mongolica* var. *tenuifolia*..

Essential oil content was highest at 1mM sulfate ion treatment however, was shown little difference among the other treatments(Fig. 3). It was reported that herb and essential oil yields increased with fertilizer application in lemon-grass(Miyazaki, 1959), bergamot mint(Rao, 1983) and Japanese mint(Kothari et al., 1987). Haelvae(1987) also reported that the optimum fertilizer application increases the herb and essential oil yields but the relation between fertilizer application and essential oil concentration was considerably complicated. Therefore more detailed research should be carried out for essential oil content and fertilizer.

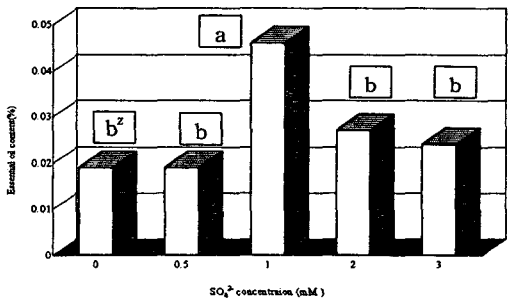

Fig. 3. The effect of SO_4^{2-} concentration on the essential oil content in *Artemisia mongolica* var. *tenuifolia*..
[z] See Table 2.

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摘 要

본 실험은 배양액 내의 황산이온이 참쑥 (*Artemisia mongolica* var. *tenuifolia*)의 생육에 미치는 영향을 알아보고자 수행되었다. 황산이온은 0, 0.5, 1, 2, 3mM의 농도로 처리되었는데 양액은 벨기에의 채소연구소에서 허브용양액으로 개발된 양액조성을 변형하여 이용하였다.

참쑥의 생육은 일반적으로 3mM 처리에서 좋았으며 건물률 또한 3mM 처리에서 가장 좋았다. 배양액내의 황산이온 농도가 증가할수록 참쑥의 엽록소 함량은 증가하였는데 특히 엽록소 a의 함량이 b함량에 비해 증가의 폭이 컸다. 참쑥의 무기물 함량은 배양액내의 황산이온 농도와 유의성을 보이지 않았으나 조직내 Ca의 함량은 3mM 처리에서 급격히 감소하였다. 식물에 의한 황산이온의 흡수는 배양액내의 농도가 증가할수록 증가하였는데 2mM까지는 서서히 증가 하다가 3mM에서 현저하게 증가하였다. 1mM 황산이온 처리에서 정유의 함량은 가장 높았으나 그 이상으로 농도가 증가할 경우 정유의 함량은 오히려 감소하였다.