Plant Res. 2(1) 26~30(1999)

Effects of added chlorides and their concentrations on growth and nitrate content in leaf lettuce(*Lactuca sativa* L.) in hydroponics.

Guang-Jae Lee, Hyun-Man Shin, Ki-Sik Kim, Cheol-Hee Lee, and Jin-Han Kim[1)]
Chungbuk Province Agriculture Research and Exension Service.
[1)]Dept. of Horticulture, Chungbuk National University, Chongju 360-763, Korea

ABSTRACT

Nitrate in edible vegetables is converted to nitrite by nitrate reductase(NR) and/or bacteria in intestines. Nitrite and amine, in the intestine of some animals and human, bind to form nitrosamine, which is toxic and known as carcinogen. This study was carried out to examine the effect of added chlorides and their concentrations on growth, yield and nitrate content in leaf lettuce plants in hydroponics. Seeds of lettuce cv. "Samsunjokchukmyon" were planted on April 29, and seedlings were planted on June 2, and were cultured until July 5 in 1998. KCl and $CaCl_2$ were used as chloride source and their concentrations were 1, 2 and 4 me/L, respectively, in the lettuce standard nutrient solution for National Horticultural Research Institute(NHRI). Completely randomized design with 3 replications was used. Nitrate content and NR activity were measured 2 and 5 weeks after planting(WAP).

The obtained results were summarized as the follows :

Leaf weight per plant was difference from harvest dates and treatments, but total leaf weight was not significantly different among treatments. Number of leaves was higher in KCl 2 me/L, $CaCl_2$ 1 me/L and control at 2 WAP than the others, and was higher in KCl 1 me/L, and control at 3 WAP than others, and was higher in control at 5 WAP. Total number of harvested leaves was the highest in control with 14, which followed by KCl 2 me/L and $CaCl_2$ 1 me/L. Nitrate content was decreased by addition of chloride in nutrient solution. Nitrate content in the 3rd and 9th leaves was significantly decreased. NR activity was higher in control and $CaCl_2$ addition treatments, while KCl addition treatments reduced NR activity. However, no direct relationship with nitrate was observed. Growth characteristics such leaf length and leaf width were not significantly influenced by chloride addition.

Key words : lettuce, nitrate, hydroponics, nutrient solution

INTRODUCTION

Lettuce is representative rice wrapped vegetable in Korea. Total cultivated area of lettuce is 6,428 ha which is 9.8% of leaf crop cultivated area, 65,457 ha in 1997(Ministry of agriculture and forestry). Cultivated area of protected lettuce is 4,376 ha which is 31.9% of 13,739 ha, total those of area.

In these days, vegetable consumer ask various crops and high quality such as no remaining chemicals and low nitrate content vegetables, increasing with their income and concerning in health.

Corresponding author: **Guang-Jae Lee,** Chungbuk Province Agriculture Research and Exension Service

Nitrate content of crops is difference from kind of crops, how to and/or when to fertilize, amounts of fertilization, weather and light conditions, harvest time, how to cultivation, and how to storage(Lee et al., 1995 ; Yang et al., 1991).

According to Lee(1997)'s and Moon(1996)'s reports : nitrate content can be reduced by breaking supplying nitrate at before harvest, and changing nitrate to chloride before 5～7days to harvest in nutrient solution. These methods can be applyed only once harvest crops, but are difficult to apply to leaf lettuce. Lee(1997) found that $(NH_4)_2CO_3$ supplying as nitrate source from planting to harvest significantly reduced nitrate contents.

Hydroponic system can increase yield and cut down period planting to harvest, and accelerate growth by optimum condition of root to compare with soil cultivation. Nitrate in leaf crops accelerate growth and is more effective fertilization than others (Sohn, 1994).

This experiment was carried out to investigate the effects of added chlorides and their concentrations on nitrate contents lettuce in hydroponic system.

MATERIALS AND METHOD

1. Variety and facilities

We tested "samsunjukcukmyon" (Heungnong Seeds), planting June 2. We used NHRI standard nutrient solution for lettuce. Chemical composition of NHRI solution is N-P-K-Ca-Mg-S = 9.2-3.6-5-3-1.5-1.5 (me/L).

This experiment carried out at plastic house with 70% shading to drop leaf temperature in Chungbuk Province Agricultural Research and Extension Service. They were made bed for hydroponics with styrofoam of 100 mm thick which size is 180×60×25 cm(L×W×H).

2. Added chlorides and their concentrations

This experiment has 7 treatments. We used NHRI solution of lettuce as control, and added chlorides to control were KCl and $CaCl_2$, and their concentrations were 1, 2, 4 me/L, respectively.

Completely randomized design with 3 replications was used.

3. Investigation of growth, nitrate, nitrate reductase (NR) activity, and yield characteristics

Leaf weight, leaf numbers, leaf length, and leaf width were investigated at 2, 3, and 5 WAP, respectively. Leaf and root characteristics of leaf lettuce seedlings were as Table 1.

Nitrate content were checked 3rd and 9th leaf at 2 and 5 WAP. We put 1 g of sample after grounding and 19 *ml* D.W. into 30 *ml* test tube. After storage 4 ℃ for 24 hrs, we filter sample liquid and measured nitrate content with pH/ISE meter(920A, Orion) nitrate electrode.

We measured nitrate reductase(NR) activity by Kaiser and Lewis' s method(1984).

RESULTS AND DISCUSSION

1. Leaf weight

Leaf weight was the highest in $CaCl_2$ 4me/L plot as 24.75g per plant at 2 WAP(Table 2). Leaf weight

Table 1. Leaf and root characteristics of lettuce seedlings before planting in the experiment.

Leaf					Root	
Weight (g/plant)	Number	Length (cm)	Width (cm)	Thickness (mm)	Weight (g/plant)	Maximum length(cm)
1.81±0.4	3.4±0.6	1.4±0.1	1.6±0.1	0.12±0.01	0.4±0.02	11±0.1

Table 2. Leaf weight at 2, 3 and 5 weeks after planting according to added chlorides and their concentrations of chlorides in summer hydroponics.

Added chlorides	Chloride concentrations (me/L)	Leaf weight(g/plant) Weeks after planting 2	3	5	Total leaf weight (g/plant)
Potassium chloride	1	21.71 a[z]	16.50 a	15.26 a	53.47 a
	2	23.25 a	13.99 ab	14.73 ab	51.97 a
	4	21.37 a	15.84 a	12.30 bc	49.51 a
Calcium chloride	1	24.68 a	12.73 bc	12.03 c	49.44 a
	2	24.05 a	10.67 c	14.95 a	49.67 a
	4	24.75 a	12.75 bc	12.30 bc	49.80 a
Control		24.14 a	16.30 a	13.75 bc	54.19 a

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

a plant in added $CaCl_2$ plot at 3 WAP was lower as 10.67 ~12.75 g than those of added KCl and control. Leaf weight at 5 WAP was the highest in the added KCl 1 me/L plot as 15.26 g a plant, and the lowest added $CaCl_2$ 1me/L as of 12.03 g. There is significantly difference from harvest dates among treatments, and is no difference total leaf yield as of 49.44~54.19 g a plant affected by treatments.

These results were concorded Liu and Shelp(1996) reports : there is no difference total leaf yield affected by added chlorides and their concentrations in Broccoli.

2. Leaf numbers, length, and width

Harvested leaf numbers were similar to leaf weight' s trend. Leaf numbers were 4.4~5.2 leaves a plant at 2 WAP according to different treatments, and were 3.0~3.5 leaves at 3 WAP, and were 4.6~5.4 leaves at 5 WAP(Table 3). Total leaf numbers were no difference with 7 treatments as of 12.1~14.0 leaves, but those of added chloride plots fewer than control by 0.7~1.9 leaves.

Leaf appearance average speed was 0.4 leaf a day, but were decreased with increasing air temperature. Leaf length was the longest in the plot of control and the shortest in KCl 4 me/L treatment. Leaf width was the largest in the plot of $CaCl_2$ 2 me/L, and the shortest in KCl 4 me/L treatment.

Table 3. Leaf number per plant at 2, 3 and 5 weeks after planting according to added chlorides and their concentrations in summer hydroponics.

Added chlorides	Chloride concentrations (me/L)	No. of leaves per plant Weeks after planting 2	3	5	No. of total leaves per plant	Leaf Length (cm)	Width (cm)
Potassium chloride	1	4.8 b[z]	3.4 ab	4.6 b	12.8 a	17.7	17.6
	2	5.2 a	3.2 bc	4.8 b	13.2 a	17.4	17.3
	4	4.4 c	3.0 d	4.7 b	12.1 a	17.3	17.1
Calcium chloride	1	5.2 a	3.1 cd	4.8 b	13.1 a	17.6	17.4
	2	4.8 b	3.0 d	4.9 b	12.7 a	17.7	17.8
	4	4.8 b	3.2 bc	4.6 b	12.6 a	17.6	17.5
Control		5.1 ab	3.5 a	5.4 a	14.0 a	17.4	0.17

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

Table 4. Nitrate contents of 9th leaf according to added chlorides and their concentrations in nutrient solution in lettuce hydroponics.

Added chlorides	Chloride Concentrations (me/L)	Nitrate contents(mg · kg^{-1} FW)	
		3rd leaf	9th leaf
Potassium chloride	1	951.6 ab[z]	699.3 ab
	2	776.7 ab	1001.3 ab
	4	882.7 ab	701.3 ab
Calcium chloride	1	932.0 ab	638.0 b
	2	806.7 ab	792.4 b
	4	456.9 c	732.0 ab
Control		1056.4 a	870.0 a

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

3. Nitrate content

Added chloride in nutrient solution made low nitrate content in leaf lettuce. Nitrate content of 3rd and 9th leaf were the lowest in the plot of KCl and $CaCl_2$ 2 me/L treatments, respectively(Table 4). Excepting $CaCl_2$ 2 me/L treatment, nitrate content in lettuce was high concentration at early stage, but relatively reduced at late growth stage.

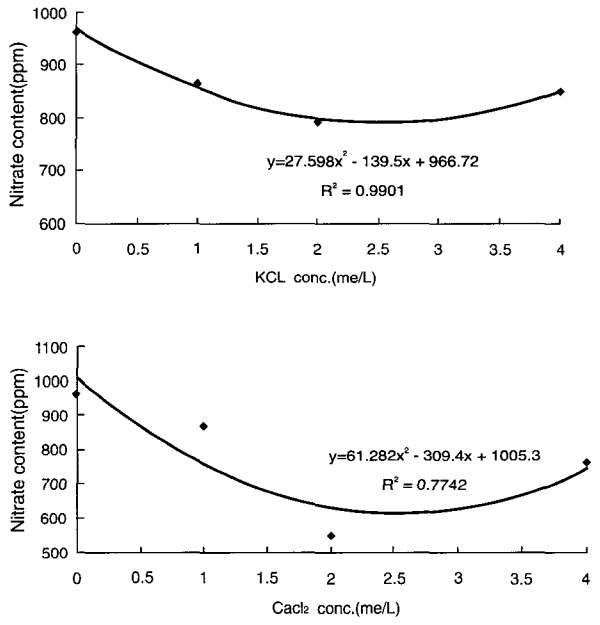

Fig. 1. Relationships between concentration of KCl and $CaCl_2$ and nitrate content in leaf lettuce hydroponics.

These results are concorded Barczak and Majcherczak (1995) report : nitrate content was relatively reduced at late growth stage than early growth stage. According to report of Inral et al.(1995), chloride in nutrient solution reduced nitrate content 5,816 ppm to 4,299 ppm in onion. And Lee et al.(1995) reported that chloride supplying, instead of nitrate before harvest, reduced nitrate about 32%. We was reduced 7.2~56.8% nitrate content by added chlorides in nutrient solution all growth stage. This experiment obtained reducing nitrate content method in lettuce to supplying chlorides all stage. It was different reducing nitrate content from other methods which were supplyed chloride instead of nitrate only once harvest crops for a week before harvest or were not supplyed nitrate late stage.

Optimum KCl and $CaCl_2$ concentrations for reducing nitrate content were 2.5 me/L, respectively, in nutrient solutions(Fig. 1).

4. NR activity

NR actvity was the highest in $CaCl_2$ 1 me/L treatment as of 2.977 μmoles · g^{-1} and was the lowest treatment in KCl 2 me/L as 2.553 μmoles · g-(Table 5). There is no significant difference among treatments, and there is no concerning directly NR activity with nitrate content, and between nitrate and nitrite content.

Table 5. Nitrate reductase activity of 9th leaf according to added chloride and their concentrations in nutrient solution in lettuce hydroponics.

Added chlorides	Chloride Concentrations (me/L)	NR activity (μmoles $NO^2 \cdot g^{-1}$ FW)
Potassium chloride	1	2.5748 a[z]
	2	2.5532 a
	4	2.6828 a
Calcium chloride	1	2.9768 a
	2	2.9552 a
	4	2.7841 a
Control		2.9752 a

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

This results were concorded with Yang(1992)' s research : there is no concerning directly NR activity with between nitrate and nitrite content.

LITERATURE CITED

Barczak, B., E. Majcherczak. 1995. Vegetables quality estimation with special consideration related to nitrate contents. Zeszyty Naukowe Academii Technicznо Rolniczej Bydgoszcy. Rolnictwo no. 36:71～85.

Inral, A., A. Gunes, and M. Aktaas. 1995. Effects of chloride and partial substitution of reduced forms of nitrogen for nitrate in nutrients of onion. J. of plant nutrition. 18:2219～2227.

Kaiser, J. J. and O.A.M. Lewis. 1984. Nitrate reductase and glutamine synthetase activity in leaves and roots of nitrate-fed *Helianthus annuus* L. Plant and soil. 70:127～130.

Lee, Eung-ho. 1997. Studies on the reduction of nitrate content and the enzyme activities related with nitrogen assimilation of leaf lettuce(*Lactuca sativa* L.) and water dropwort(*Oenanthe stolonifera* DC.) grown with hydroponics. Seoul nat' l Univ. ph D report.

Lee, Eung-ho, Jae-wook Lee, Ji-sun Kwon. 1995. Studies on leaf vegetable quality improvement of grown by hydroponics. The research annual reports of R.D.A. in 1994. NHRI. pp 500～505.

Liu, L.X. and B.J. Shelp. 1996. Impact of chloride on nitrate absorption and accumulation by Broccoli (*Brassica Oleracea* var. *Italica*). Candian J. of Plant Science. 76:367～377.

Ministry of agriculture and forestry. 1998. Statistical year book of agriculture & forestry. pp 81～82.

Mun, Bo-hum. 1996. Reduction method of nitrate content and quality improvement in hydroponocally grown *Oenanthe stolonifera* DC. Seoul National University. Master of agriculture report.

Sohn, S.M. 1994. NO_3^- accumulation in edible parts of chinese cabbage and radish cultivated by conventional and organic farming and its limit value for safe agricultural products. The 10th FOAM Conference. Lincoln University. Christchurch / NewZealand. p. 139.

Yang, Yong-joon, Kuen-woo Park, and Jin-cheol Jeong. 1991. The influence of pre- and post-harvest factors on the shelf-life and quality of leaf lettuce. Korean J. Food Sci. Tecnol. 23:133～140.

Yang, Y.J. 1992. Effect of storage treatment on NO_3^- and NO_2^- contents in vegetables. J. Kor. Soc. Hort. Sci. 33:125～130.

Received March 15, 1999
Accepted May 15, 1999