Journal of Bio-Environment Control, 12(1):26~29, (2003)

Response of Growth and Photosynthesis of Pepper Seedlings to Potassium Fertilizer

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칼리처리가 고추 플러그묘의 생육과 광합성에 미치는 영향

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Abstract. Experiments were conducted to estimate optimal potassium strength in the nutrient solution for 'Nokgwang' and 'Kwari' green pepper seedlings cultured in small plug-cell trays. Plant height, stem diameter, and leaf area increased with increasing K concentration, with greater effect on 'Kwari' than 'Nokgwang'. Total dry weight increased by increasing potassium strength. 'Kwari' had heavier dry weight than 'Nokgwang'. Chlorophyll content differed by cultivars and potassium strength. The highest chlorophyll content was obtained at 2.0 strength potassium in 'Nokgwang', but not in 'Kwari'. Net photosynthesis was greater in plants fertilized with 1.5 strength potassium for 'Nokgwang' and 2.0 strength potassium for 'Kwari' than the other treatments.

Key words : potassium, photosynthesis, chlorophyll, stomatal conductance

Introduction

Vegetable seedlings cultured for transplanting in small-size plug cells require careful management (Daufault and Waters, 1985) due to the volume limitations of the cell and the high seedling densities within the tray. Essential nutrient elements within the plug cell are frequently insufficient to sustain plant growth for an extended period. A proposed fertilization scheme (Widers, 1989) for culture of pepper seedlings involves application of moderately low concentration nutrient solutions. Potassium is normally the major role element for the maintenance of turgor, stomatal control and regulation of plant water content (Hsiao and Läuchli, 1986). As well as this biophysical role, K fulfils biochemical functions in the cytoplasm for the activation numerous enzymes (Wyn Jones and Pollard, 1983). Leigh et al. (1999) proposed that the onset of growth reductions due to decreased K supply, and hence critical K concentrations, corresponded to the onset of decline in cytoplasmic K concentrations and disruption of biochemical functions.

The objective of this study was to determine the influence of potassium fertilization in small plug-cell on the seedling growth and photosynthetic rate of green peppers.

Materials and Methods

Field experiments were conducted at the Miryang National University Horticulture Research field in Miryang. In all experiments, seeds of 'Nokgwang' and 'Kwari' green pepper were sown in 32-cell plug trays containing a peat-based TK_2 medium on 4 April, 1997. Plants were grown in a glasshouse under natural conditions. Potassium was applied at 0, 0.5, 1.0, 1.5, and 2.0 strength of Yamajaki's solution. The experimental design in the field trial was 2×4 factorial in a randomized complete block with three replications. The factors included cultivars and potassium concentrations.

For growth analysis, plants were excavated at 15 days intervals during seedling growth after bedding. Fresh tissue was rinsed in tap water and dried at 70°C in a forced-

air oven for 2 days. Individual plant shoot, leaf, and root dry weight were measured.

The Minolta SPAD 502 meters was used to obtain chlorophyll content on the third leaf from the top of plant.

Net photosynthesis, transpiration, and stomatal conductance were obtained using a portable photosynthesis system (Model 6400, LI-COR, Lincoln, Nebraska, USA). Mean relative humidity, temperature, and CO_2 concentration in leaf chamber during measurements were 65±7%, 28±2°C, and 360±28 mg·L^{-1}, respectively. Three plants per treatment were randomly selected on 60 days after bedding. Data analysis for mean comparisons was made using Duncan's multiple range test at p=0.05 and 0.01.

Results and Discussion

The plant height and stem diameter of 'Nokgwang' and 'Kwari' increased with increasing K concentration (Table 1). These effects were also reflected in a dry weight of shoots. Potassium efficiency ratio declined with increasing K concentration, which indicates decline in the internal utilization of K to produce dry mass.

The response curves of leaf area were significantly different for 'Nokgwang' and 'Kwari' cultivars (Fig. 1). Mean leaf area were 9.4, 23.1, 36.7, 38.8, and 46.4 cm^2 for plants fertilized with 0, 0.5, 1.0, 1.5, and 2.0 strength potassium for 'Nokgwang', and 19.1, 39.0, 57.2, 59.0, and 78.6 cm^2 for plants fertilized with 0, 0.5, 1.0, 1.5, and 2.0 strength potassium for 'Kwari', respectively. Total dry weight increased by increasing potassium strength (Fig. 2).

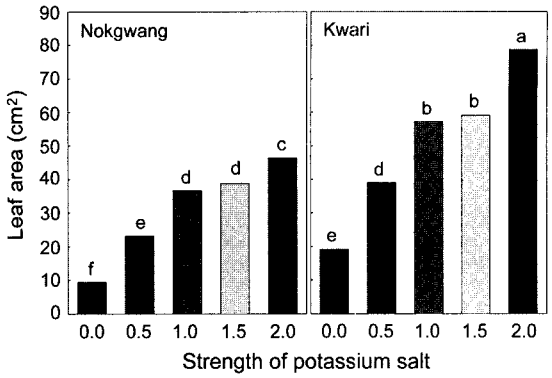

Fig. 1. Effect of potassium strength in nutrient solution on leaf area of green pepper (cv. 'Nokgwang' and 'Kwari') in plug system. Mean separation within treatments by DMRT at 5% level.

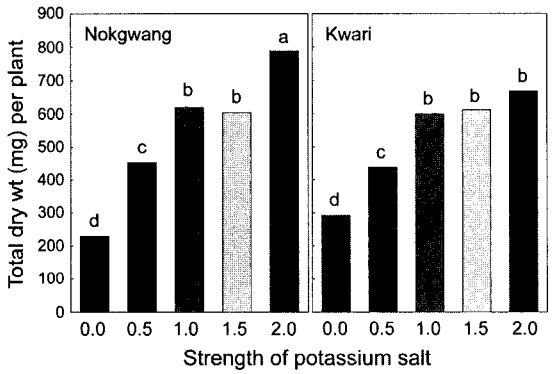

Fig. 2. Effect of potassium strength in nutrient solution on plant dry weight of green pepper (cv. 'Nokgwang' and 'Kwari') in plug system. Mean separation within treatments by DMRT at 5% level.

Table 1. Effect of K strength in nutrient solution on plant height, stem diameter, and leaf weight of pepper grown in plug system.

Cultivar	Strength of potassium	Plant height (cm)	Stem diameter (cm)	Leaf weight (g)
Nokgwang	0.0	7.48 f[z)]	0.25 e	0.436 e
	0.5	13.32 d	0.32 bc	1.026 d
	1.0	20.10 b	0.35 ab	1.494 c
	1.5	22.34 a	0.36 a	1.616 c
	2.0	19.88 b	0.35 a	1.918 b
Kwari	0.0	9.62 e	0.246 e	0.592 e
	0.5	16.36 c	0.286 d	1.090 d
	1.0	20.56 b	0.310 cd	1.574 c
	1.5	19.18 b	0.314 c	1.680 c
	2.0	23.74 a	0.344 ab	2.174 a

[z)]Mean seperation within columns by DMRT at 5% level.

The leaf area was an important factors for photosynthesis. The absorption of light through leaf is determined by not only pigment concentration but also leaf size, leaf surface reflectivity, light scattering, and pigment distribution in leaf. Chlorophyll content was an important factor for increasing photosynthetic rate. Fig. 3 shows the effect of potassium strength in nutrient solution on chlorophyll content. Chlorophyll content differed in response to cultivars and potassium strength. The highest concentration of potassium gave the higst chlorophyll content in 'Nokgwang', but not in 'Kwari'. Chloroplast

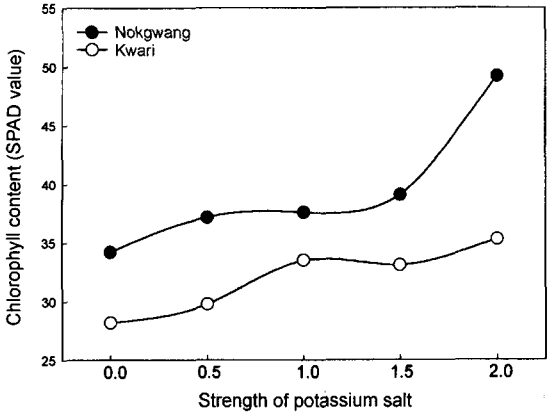

Fig. 3. Effect of potassium strength in the nutrient solution on chlorophyll content (SPAD value) of green pepper (cv. 'Nokgwang' and 'Kwari') in plug system.

number in mesophyll cells was influenced by mineral nutrition (Porokhnevich, 1972; Weiland, et al., 1975). From these results, we thought that potassium is related with chlorophyll content.

Net photosynthesis was higher for plants fertilized with 1.5 strength K for 'Nokgwang' and 2.0 strength K for 'Kwari'. In contrast, higher concentrations of potassium reduced photosynthesis in 'Nokgwang', but not in 'Kwari'. Pepper seedlings obtained with 1.0 and 1.5 strength K produced higher rates of stomatal conductance and transpiration for 'Nokgwang'. But with 'Kwari' increasing concentration of potassium up to 2.0 strength K resulted in increasing stomatal conductance and transpiration rate.

The effects of nitrogen on photosynthesis during leaf ontogency were greater than those of phosphorus or potassium (Osman, et al., 1977). Trifoliate leaves of potassium-stressed soybean seedlings fixed 38% less CO_2 than did control leaves (Wells et al., 1979). Fully developed mature bean leaves were much less sensitive to potassium deficiency than were growing leaves (Ozbun, et al., 1965). Potassium is involved in transfer process in chloroplasts and play a structural role in the photosynthetic apparatus. Elevated K fertilization during bedding plant production may reduce irrigation demand and moisture stress during marketing and landscape establishment. Lindhauser (1985) indicated increasing K fertilizer concentration reduced transpirational water loss and decreased the influence of moisture stress on gas

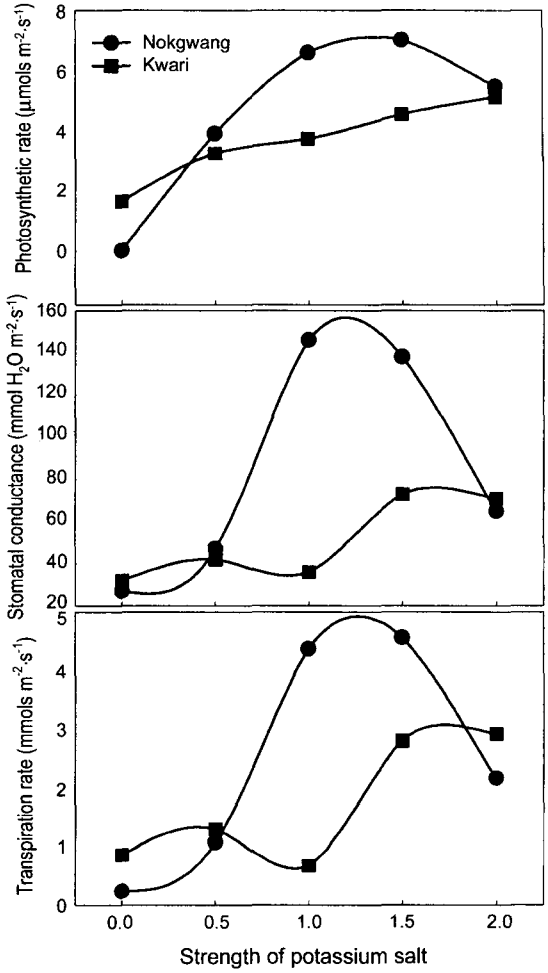

Fig. 4. Effect of potassium strength in the nutrient solution on photosynthetic rate, stomatal conductance and transpiration rate of green pepper (cv. 'Nokgwang' and 'Kwari') in plug system.

exchange for sunflower. Considering all factors in pepper seedling and photosynthesis, these results suggest that increasing K fertilizer concentrations may improve the tolerance of pepper to moisture stress by reducing transpirational water loss and allowing photosynthesis. Therefore, we assumed that higher potassium fertilizer increased total dry weight.

적 요

풋고추 플러그 육묘시에 칼리의 최적 시비농도를 구명하기 위하여 32구 플러그 트레이에 TK_2를 채운 다음 종자를 파종하여 칼리를 농도별로 처리하여 식물

체의 생육과 광합성에 미치는 효과를 조사하였다. 초장, 줄기 직경, 엽면적 및 총 건물중은 K의 농도가 증가할수록 생육이 촉진되었으며, '녹광' 보다는 '꽈리'의 생육이 더 좋았다. 품종과 K의 농도에 따라서 엽록소의 함량은 차이가 있었는데, '녹광'은 K의 농도가 2.0배까지 높을수록 증가하였으나 '꽈리'는 1.0배 이상의 농도에서는 차이가 거의 없었다. 순광합성율은 '녹광'의 경우에는 1.5배의 농도에서 '꽈리'의 경우에는 2.0배의 고농도에서 가장 높았으며, 기공전도도와 수분증발율도 순광합성율과 비슷한 경향이었다.

주제어 : 칼리, 광합성, 엽록소, 기공전도도

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