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# Effect of Ionic Salt Strength on the Growth and Photosynthetic Rate of Pepper Plug Seedlings

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# 무기 이온의 농도가 고추 플러그묘의 생육과 광합성에 미치는 영향

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**Abstract.** Experiments were conducted to investigate optimal ionic salt strength in nutrient solution for small plug seedlings of ‘Nokgwang’ and ‘Kwari’ green pepper. Plant height increased with increasing ionic salt strength. Total leaf area was 72% greater in ‘Nokgwang’ and 18% greater in ‘Kwari’ with 2.0 ionic salt strength than that with 1.0 strength. Dry weight per plant tended to increase at higher ionic salt strengths in ‘Kwari’, but to decrease in ‘Nokgwang’. Chlorophyll content increased with increasing ionic salt strength in both cultivars. Photosynthetic rate, stomatal conductance, and transpiration rate were higher for plants fertilized with 1.5 strength than other strengths in both cultivars. Photosynthetic rate peaked at 8.74 $\mu mol \cdot m^{-2}s^{-1}$ in ‘Nokgwang’ and 5.70 $\mu mol \cdot m^{-2}s^{-1}$ in ‘Kwari’ with 1.5 ionic salt strength.

**Key words :** chlorophyll, ionic salt strength, photosynthetic rate, stomatal conductance

## Introduction

Pepper has been consumed as spice and vitamin source in Korea. In recent years, major changes have been occurred in the production system of seedlings. However, only a few studies are available regarding the effect of macronutrients on the growth of plug seedlings. Nutrient uptake from soil depends on plant demand and soil supply and several mathematical models simulating the dynamic-interaction between these processes have been developed (Baldwin et al., 1973; Barber and Cushman, 1981; Classen and Barber, 1976; Classen, et al., 1986). These models were based on the same principles and differ only in detail. In the models, ions were transported to roots by mass flow and diffusion and are absorbed at rates which depend on their concentrations at the root surface as expressed in a plug system. Only a few studies have focused on the relationship between photosynthesis and plant productivity or growth (Zelitch, 1982), and reported the photosynthetic rate and chlorophyll contents as related to ionic strength.

The objective of this study was to determine the influence of ionic strength on the growth, chlorophyll content, and apparent photosynthetic rate of green pepper plug seedlings.

## Materials and Methods

Field experiments were conducted at the Miryang National University Horticulture Research field, Miryang. In all experiments, seeds of ‘Nokgwang’ and ‘Kwari’ green peppers were sown in 32-cell plug trays containing a peat-based $TK_2$ medium. Seeds of pepper were sown on April 4, 1997 and seedlings were grown in a glass-house under natural conditions. Ionic salts were applied with 0, 0.5, 1.0, 1.5, and 2.0 strength of Yamazaki’s solution (Yamazaki, 1982). The experimental design in the field trial was 2×4 factorial in a randomized complete block with three replications. The factors included were cultivar and ionic salt strength.

For the growth analysis, plants were excavated at 15 days intervals during seedling growth after seeding. Fresh tissue was rinsed in tap water and dried at 80°C in a forced-air oven for 2 days. Individual plant shoot, leaf and root dry weight were measured at 45 days after sowing. The chlorophyll meter (Minolta SPAD 502) was used to obtain chlorophyll content on the third leaf from the top of plant.

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

## Results and Discussion

The effect of ionic salt strength during seedling growth was evaluated for green peppers (Fig. 1). Plant height increased with increasing ionic salt strength. Growth of 'Kwari' was greater than that of 'Nokgwang'. This could be explained from the fact that ionic salt efficiency ratio is equivalent to the reciprocal of ionic salt strength in plants, and ionic salt efficiency ratio corresponded to differences in cultivars.

Total leaf area was 72% greater in 'Nokgwang' and

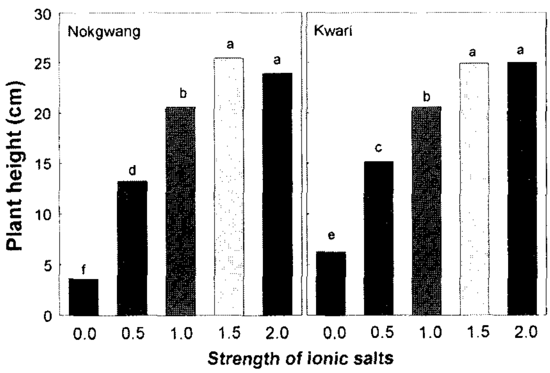


**Fig. 1.** Effect of ionic strength in nutrient solution on plant height of green pepper (cv. 'Nokgwang' and 'Kwari') plug seedling. Mean separation within treatments by Duncan's multiple range test at 5% level.

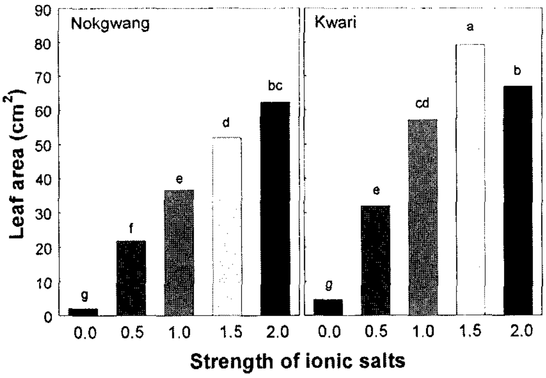


**Fig. 2.** Effect of ionic strength in nutrient solution on leaf area of green pepper (cv. 'Nokgwang' and 'Kwari') plug seedlings. Mean separation within treatments by Duncan's multiple range test at 5% level.

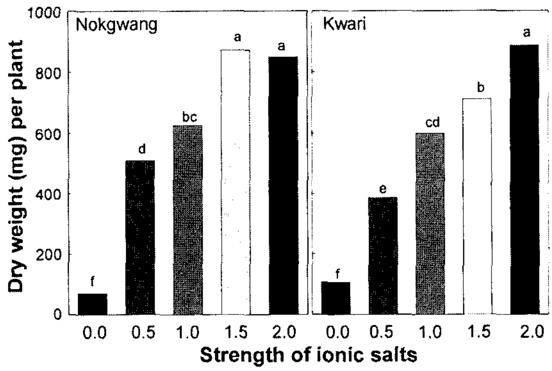


**Fig. 3.** Effect of ionic strength in nutrient solution on plant dry weight of green pepper (cv. 'Nokgwang' and 'Kwari') plug seedlings. Mean separation within treatments by Duncan's multiple range test at 5% level.

18% greater in 'Kwari' with 2.0 strength than that of the control (1.0 strength). However, zero strength solution reduced total leaf area by 17 and 13 times for 'Nokgwang' and 'Kwari', respectively. At low ionic salt supply, growth and leaf area of both cultivars were remarkably reduced. There was even a tendency of decreasing dry weight of 'Nokgwang' at 0 ionic salt strength.

The response curves of shoot dry mass and ionic strength were significantly different for 'Nokkwang' and 'Kwari' cultivars. Mean total plant dry weights was 70, 510, 626, 872, and 850 mg for plant fertilized with 0, 0.5, 1.0, 1.5, and 2.0 strength for 'Nokgwang', and 106, 386, 600, 712, and 886 mg for plant fertilized with 0, 0.5, 1.0, 1.5, and 2.0 strength of ionic salts for 'Kwari', respectively. 'Nokgwang' had larger dry weight than 'Kwari'. Dry weight tended to increase at higher ionic salt supply for 'Kwari', but to decrease in 'Nokgwang' at 2.0 strength. The leaf growth of 'Kwari' was much more vigorous at all developmental stages than that of 'Nokgwang'.

Metabolic activities of plants such as phytohormone production, photosynthetic rate, photoperiodism, and production of ATP can increase nutrient uptake or utilization by influencing root morphology and function. Differences among cultivars in nutrient uptake per unit dry mass or length, or differences in root morphological characteristics such as shoot:root ratio, may also indicate mechanisms for increased nutrient aquisition at low nutrient availabilities (Classen and Barber, 1976). The major advantages for adopting SPAD technology are speed of measurement, simplicity, and convenience. Several nondestructive measurements can be reached before leaving the field. The results shown in Fig. 4 indicate that chlorophyll content was different in response to cultivars and ionic salts strength. The highest chlorophyll content was obtained at 2.0 strength in both cultivars.

Previous studies have reported that chloroplast number in mesophyll cells was influenced by pruning (Golika, 1966), mineral nutrition (Weiland et al., 1975), and environmental conditions in natural localities (Goryshina et al., 1981). Ultrastructural changes, induced in the leaves by mineral deficiency, resemble those induced by viral infection. Various metal cation and other mineral ion deficiencies may influence the ontogeny of chloroplast structure, especially those of nitrogen, magnesium, calcium, iron,

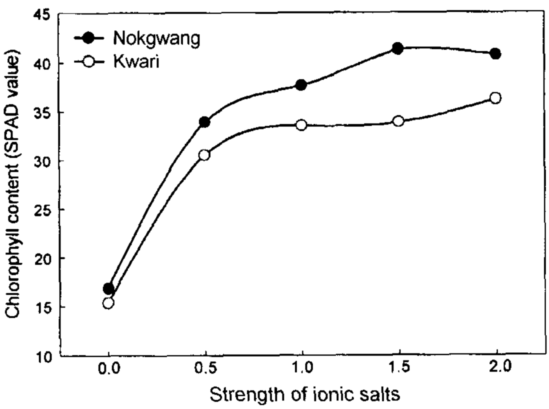


**Fig. 4.** Effect of ionic strength in nutrient solution on chlorophyll contents (SPAD value) of green pepper (cv. 'Nokgwang' and 'Kwari') plug seedlings.

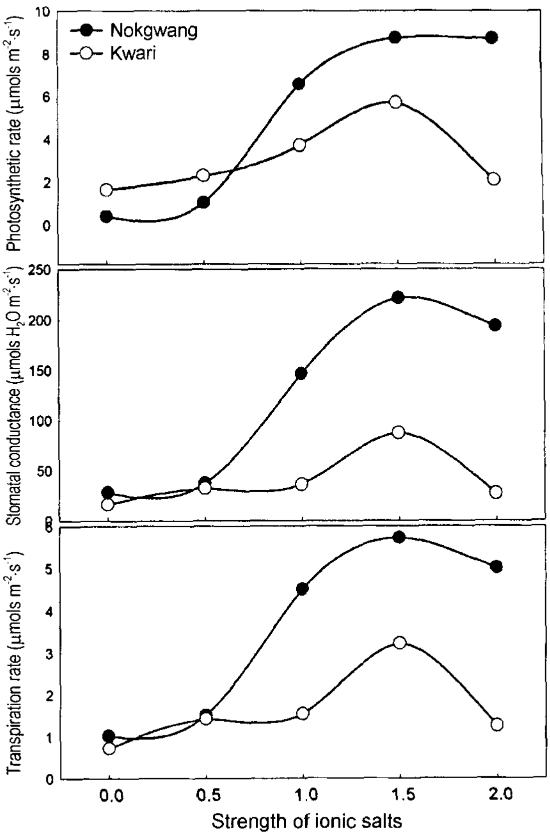


**Fig. 5.** Effect of ionic strength in nutrient solution on photosynthetic rate, stomatal conductance, and transpiration rate of green pepper (cv. 'Nokgwang' and 'Kwari') plug seedlings.

and manganese (Sundqvist et al., 1980). These results indicated that lack of minerals and alterations in the proportions of the elements taken up by the plant can affect the chlorophyll content and the number, and ultrastructure of the chloroplasts.

Photosynthetic rate, stomatal conductance, and transpiration rate were higher in plants fertilized with 1.5 strength than those of other treatments in both cultivars, peaking at 8.74 $\mu$mol · $m^{-2}$ · $s^{-1}$ in 'Nokgwang' and 5.70 $\mu$mol · $m^{-2}$ · $s^{-1}$ in 'Kwari'. Photosynthetic rate and respiration rate were affected in a wide variety of ways by the nutrient supply. Difference in stomatal conductance was detected among plants grown at the various ionic concentrations.

Leaf stomatal conductance increased linearly with increasing ionic salt strength. Although photosynthetic rate was not always well correlated with growth, Friend and Helson (1976) reported that increased growth rates at elevated day temperatures resulted from higher photosynthetic rate. In our results, increase of stomatal conductance and transpiration rate were always accompanied by photosynthetic rate enhancement attributable to ionic salts strength, which suggests that stomatal apparatus may affect photosynthetic rate through ionic salt strength. In soils not seriously deficient in particular nutrients, the availability of minerals is less critical for photosynthetic rate than the climatic factors. Nevertheless, photosynthetic rate can almost always be enhanced by the artificial provision of nutrients. Mineral nutrients exert their influence on the intensity of carbon metabolism directly, and via growth and morphogenesis. It is suggested that mineral nutrients also influence gas exchange by their effects on morphogenesis (i.e. growth, size and structure of leaves, shoots and roots) and on the course of development (e.g. life span).

## 적 요

풋고추의 육묘관리시에 최적 시비농도를 구명하기 위하여 무기이온을 농도별로 처리한 다음 식물체의 생육과 광합성에 미치는 효과를 조사하였다. 초장은 무기이온의 농도가 증가할수록 길었으며, 표준농도인 1.0배를 시비한 것보다 2.0배의 고농도로 시비하였을 때에 '녹광'은 72%, '꽈리'는 18% 신장생장이 촉진되었다. 건물중은 '꽈리'의 경우에 무기이온의 농도가 높을수록 증가하였으나, '녹광'의 경우에는 고농도인 2.0배 처리시에는 오히려 감소하였다. 엽록소의 함량은 무기이온의 농도가 2.0배까지 높을수록 증가하였다. 광합성속도, 기공전도도 및 증산속도는 두 품종 모두 1.5배의 농도로 관주하였을 때에 가장 높았는데, 이때의 광합성속도를 비교하면 '녹광'은 8.74 $\mu mol \cdot m^{-2} \cdot s^{-1}$, '꽈리'는 5.70 $\mu mol \cdot m^{-2} \cdot s^{-1}$로서 생육이 왕성하였던 '녹광'의 광합성속도가 더 높았다.

**주제어** : 무기이온 농도, 광합성, 엽록소, 기공전도도

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