Genetics and Plant Physiology – 2012, Volume 2 (1–2), pp. 50–56

Available online at http://www.ifrg-bg.com

EFFECTS OF MINERAL STRESS ON THE VEGETATIVE DEVELOPMENT OF GREENHOUSE-GROWN BELL PEPPER PLANTS

Leonardo M.[1], F. Broetto[1*], J. A. Marchese[3], D. F. Bressan[1], D. J. Marques[2], R. B. S. Coscolin[1]

[1]*Department of Chemistry and Biochemistry, Institute of Biosciences, São Paulo State University (UNESP), 18618-000 Botucatu, SP, Brazil*

[2]*Department of Natural Resources, Faculty of Agronomy, São Paulo State University (UNESP), 18603-970 Botucatu, SP, Brazil*

[3]*Laboratory of Biochemistry and Plant Physiology, College of Agronomy, Parana Federal University of Technology (UTFPR), 85503-390 Pato Branco, PR, Brazil*

Received: *30 March 2012* Accepted: *15 October 2012*

Summary. The aim of this study was to evaluate the effects of mineral stress induced by fertigation on vegetative parameters of bell pepper (*Capsicum annuum* L.) grown in a protected environment. Subsequent applications of $Ca(NO_3)_2$ and KCl were adopted to change the electrical conductivity (EC) of the soil, which ranged from 1.5 (control) to 6.0 dS m^{-1}. Organic matter was applied simultaneously to half of the plots to evaluate the possible attenuation of the effects produced by soil salinization. A significant difference was observed in the number of totally expanded leaves and plant height between the different levels of soil EC. Application of organic matter to the soil was unable to attenuate the salinity effects of the treatments.

Keywords: *Capsicum annuum* L.; fertigation; salt stress; salinization.

Abbreviations: cv – Cultivar; DAP – Days after planting; DW – Dry weight; dS – DeciSiemens; EC – Electrical conductivity; OM – Organic matter.

INTRODUCTION

Bell pepper plants are slow growing until approximately 75 days after planting (DAP), with low extraction of nutrients (Marcusse and Vilas Boas, 2000). Thereafter, an increase of nutrient absorption is observed until 90 DAP, especially during the stage of fructification. This rule does not apply to Ca^{2+} and Mg^{2+} cations, whose maximum absorption occurs only at the end of the growth cycle (Santiago and Goyal, 1985; Filgueira, 2000). This fact may explain the low productivity of bell pepper, which is moderately sensitive to salinity (Gal et al., 2008) when grown at an electrical conductivity (EC) of up to 1.5 dS m^{-1}

*Corresponding author: broetto@ibb.unesp.br

(Mass and Hoffman, 1977; Medeiros, 1998).

Nutritional disorders may occur in saline soils that can cause antagonistic relationships between nutrients in the plant, significantly reducing the profit made from plantations (Grattan and Grieve, 1993; Santos and Muraoka, 1997; Ashraf and Foolad, 2007; Esteves and Suzuki, 2008; Mgbeze and Omodamwen, 2011). Nutrients need to be available in the form of dissolvable salts and at an adequate ionic balance in the soil solution. The use of fertigation systems in greenhouses is increasing in Brazil since they are easy to implement and reduce production costs. Despite these advantages, this practice is associated with risks, particularly the accumulation of salts on the soil surface and in the peripheral root zone of the bulb. Alterations in nutrient availability may occur as a result of soil salinization due to incorrect handling of the system, with physiological consequences for plant development.

The aim of the present study was to evaluate the effects of high concentrations of nutrients applied by fertigation on the biometric parameters of bell pepper grown in a protected environment.

MATERIAL AND METHODS

The experiment was carried out in a plastic tunnel greenhouse located in Botucatu, São Paulo, Brazil. Bell pepper (*Capsicum annuum* L.) seeds were sown and the plantlets were transferred to 30-liter pots (36.0 x 36.0 x 30cm) containing dark red dystrophic soil with the following chemical characteristics: pH 4.2; 14 g dm^{-3} organic matter; 2 mg dm^{-3} P (resin method); 0.2, 4 and 1 mmol dm^{-3} K, Ca and Mg, respectively.

For correction of soil acidity, dolomitic limestone was applied previously to increase initial soil base saturation to 80%. A total of 150 mg phosphorus L^{-1} soil was applied, 75 mg as P_2O_5, and 75 mg as thermal phosphate containing S and micronutrients (Villas Bôas, 2000). In addition, 260 g organic matter was added to each variant (~ 20 t ha^{-1}). The plants were transferred to the pots 50 days after sowing and freely grown in 2 or 3 stems. A completely randomized block design with four replications in a 4x2 factorial arrangement was used, which consisted of 4 doses of the fertilizer supplemented or not with organic matter. For the control treatments, 0.24 g N $plant^{-1}$ [$Ca(NO_3)_2$] and 0.2 g K $plant^{-1}$ (KCl) were applied to each pot at intervals of 3 days, maintaining the soil EC at about 1.5 dS m^{-1} (the limit for bell pepper).

On the basis of the equations used to estimate soil salinity (EC = 0.053g $Ca(NO_3)_2$ + 0.4029 and EC = 0.0967g KCl + 0.38), the equivalent amounts of $Ca(NO_3)_2$ and KCl were applied to increase EC to 3.0, 4.5 and 6.0 dS m^{-1}. The fertilizers were applied in solution using an adapted fertigation system. The soil solution extractor and tensiometer were installed at a distance of 15 cm from the plant and at a depth of 20 cm from the center of the porous capsule. Electrical conductivity was monitored at intervals of 2 weeks and the dose of the fertilizers was adjusted using the soil salinity equation. Plant height and leaf number were measured at six different time points during the growth cycle. Leaf area and dry matter yield of the plants were recorded at the end of the growth cycle.

RESULTS AND DISCUSSION

The different levels of EC significantly influenced leaf number and plant height (Table 1). On the other hand, the presence or absence of organic matter or the interaction of this factor with EC level had no significant effect on the vegetative parameters studied. The leaf area did not differ significantly between treatments (F test), and the quadratic equation best fitted the data. This finding highlights a tendency for leaf area to decrease with increasing soil EC (Figure 1). In view of the fluctuations observed in conductivity, this parameter was probably little influenced since sampling was performed at the end of the growth cycle, a period that coincided with high nutrient extraction by the plant. This somehow contrasted to the results reported by Medeiros (1998) for the same species. For the control treatment (1.5 dS m^{-1}), we observed higher mean values of leaf area than those reported by Santos (2001) for the same hybrid (cv. Elisa), but grown under different experimental conditions. Although not statistically significant, the mean leaf area of the control treatment was higher (about 8%) than that obtained for plants submitted to stress EC (6.0 dS m^{-1}).

Despite the absence of a significant difference in plant dry weight (DW) (Table 1), this parameter tended to decrease with increasing soil EC as shown in Fig. 1. The DW of control plants (1.5 dS m^{-1}) was by about 14% higher than that observed for the highest EC (6.0 dS m^{-1}), a fact that might have influenced the observed alterations of other physiological parameters studied. According to Medeiros (1998) and Silva (2002), the salt index of soil can decrease the DW of the aerial part of plants.

High concentrations of potassium in soil can contribute to the occurrence of osmotic stress in plants with important nutritional problems depending on the tolerance of each species. However, Kaya and Higgs (2003) showed that application of high potassium concentrations (KNO_3) to bell pepper plants (cv. 11B 14) attenuated the effects of NaCl, maintaining the rate of dry matter accumulation for the production of fruits as well as chlorophyll concentration. The opposite effect was observed in plants treated with NaCl alone.

In the present experiment, little variation in plant DW was observed with increasing soil EC, even for the treatment using the highest level of EC. As observed

Table 1. Analysis of variance (F test) of leaf area, dry weight, leaf number, and height of bell pepper plants according to the level of electrical conductivity in the presence or absence of organic matter in the soil.

Parameter	Leaf area	Dry weight	Leaf number	Plant height
EC	0.4037	0.1328	0.0134*	0.0037**
OM	0.9098	0.5778	0.5915	0.0530
EC x OM	0.9375	0.6433	0.6302	0.1334
CV (%)	12.91	14.02	11.46	9.11

EC: Electrical conductivity; OM: Organic matter; CV: Coefficient of variation

*P<0.05, **P<0.01: Significantly different.

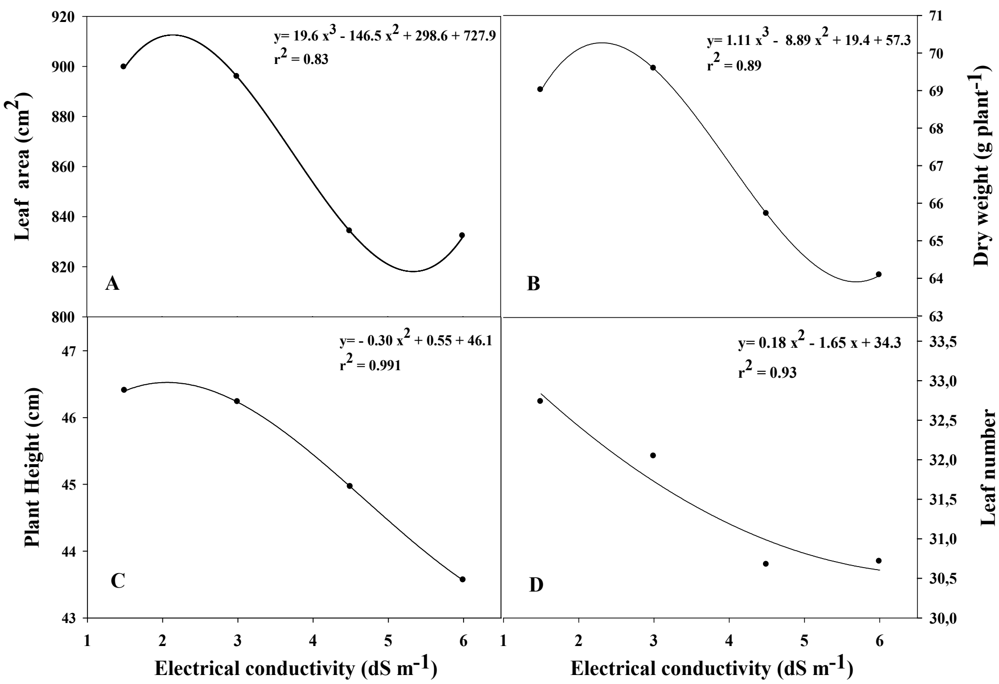

Figure 1. Biometric parameters of bell pepper plants according to the level of soil electrical conductivity. (A) Leaf area (cm^2) of 20 representative leaves; (B) mean plant (leaves + stalks) dry weight (g) at 155 day after planting; (C) height of bell pepper plants; (D) Average number of totally expanded leaves of bell pepper plants.

for the other parameters, it was suggested that nutrient extraction by the bell pepper culture, which was relatively low at about 90 DAP, together with the moderate salt tolerance of the plant (1.5 dS m^{-1}), was a decisive factor for DW accumulation during the sampling period. This observation was supported by the fact that there was little change in leaf area during the same period.

A significant difference in plant height was observed between treatments, except for those supplemented with organic matter (Fig. 1). Plant height was similar for all treatments until 90 DAP (Fig. 2), probably because of the slow growth rate of bell pepper until physiological age, attenuating possible effects of increasing EC. After 90 DAP, plant height differed between treatments, with control plants (1.5 dS m^{-1}) reaching a height that was by 7%, 20% and 26% greater than that of plants grown at soil EC of 3, 4.5 and 6.0 dS m^{-1}, respectively.

The mean plant height (80 to 90 cm) of control plants (1.5 dS m^{-1}) was similar to the values reported by Panelo (1995), Tivelli (1999) and Cunha (2001), but was higher than that found by Teodoro (1986) and lower than that reported by Santos (2001), Villas Bôas (2001), and Silva (2002). Studying the same bell pepper hybrid, Silva (2002) observed a significant decrease in plant height with increasing soil salinity. On the other hand, Medeiros (1998) showed that salinity did not significantly affect the height of bell pepper plants.

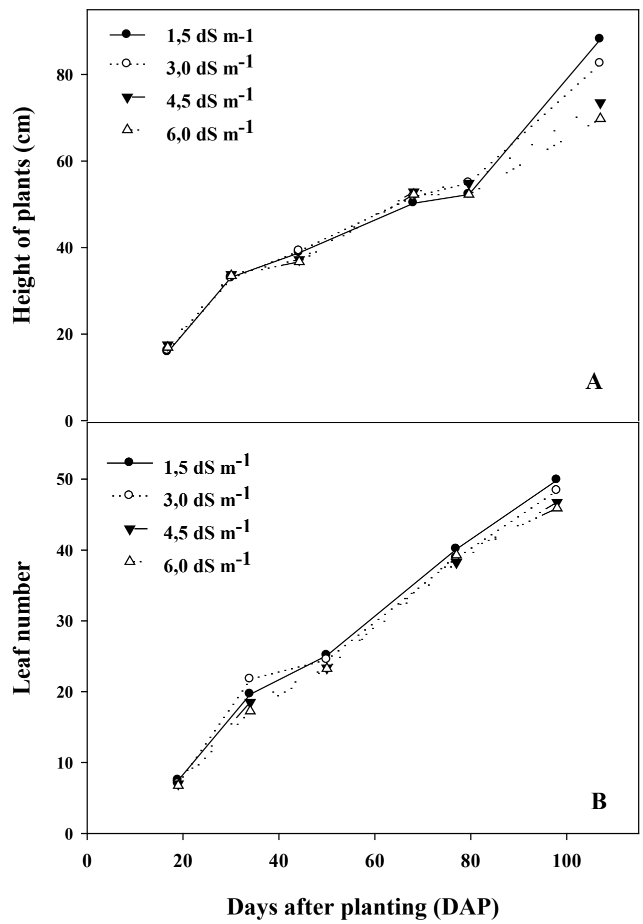

Figure 2. Mean plant height up to 121 day after planting (A) and leaf number of bell pepper plants (cv. Elisa) up to 123 day after planting (B) according to the level of soil electrical conductivity.

A significant difference was observed in the number of totally expanded leaves between treatments using different levels of EC as demonstrated by adjustment of the quadratic equation (Figure 1). The increase in soil salinity induced by excess fertilizer use may have led to a decrease in total leaf number. The number of totally expanded leaves was similar for all treatments until 90 DAP (Figure 2). Only small differences between treatments were observed after this period, with control plants (1.5 dS m^{-1}) presenting a leaf number that was by 4.6%, 8% and 11% higher than that of plants grown at EC of 3, 4.5 and 6 dS m^{-1}, respectively.

CONCLUSIONS

In conclusion, the present results suggest that an increase of soil EC after fertilizer application by fertigation interfered with the vegetative development of bell pepper plants. In addition, this interference seems to depend on the phenological phases of the plant, with emphasis on the nutrient absorption curves characteristics of the culture. Application of organic matter did not seem to effectively attenuate the salinity effects of the treatments.

ACKNOWLEDGMENTS

This work was supported by a research grant from CNPq (National Council for Scientific and Technological Development, Brasília, DF, Brazil) to M. Leonardo.

REFERENCES

Ashraf, M., Foolad, M. A. 2007. Improving plant abiotic-stress resistance by exogenous application of osmoprotectants glycine betaine and proline: Environmental and Experimental Botany. 59: 206–216.

Cunha, R.A. 2001. “Parâmetros agrometereológicos de cultura de pimentão (*Capsicum annum* L.) em ambientes protegido e campo.” Tese, Faculdade de Ciências Agronômicas – Unesp - Botucatu.

Esteves, B. S., Suzuki, M. S. 2008. Efeito da salinidade sobre as plantas. Oecol Bras. 12: 662–679.

Filgueira, F.A.R. 2000. Novo Manual de Olericultura: Agrotecnologia moderna na produção e comercialização de hortaliças. UFV, Viçosa.

Gal, A. B., Ityel, E., Dudley, L., Cohen, S., Yermiyahu, U., Presnov, E., Zigmond, L, Shani, U. 2008. Effect of irrigation water salinity on transpiration and on leaching requirements: A case study for bell peppers. Agricultural Water Management 95: 587–597.

Grattans, S.R., Grieve, C.M. 1993. Mineral nutrient acquisition and response by plants grown in saline environments, In: Pessarakli, M. (Ed.), Plant and Crop Stress. Marcel Dekker, Tucson, pp.203–226.

Kaya, C., Higgs, D. 2003. Supplementary potassium nitrate improves salt tolerance in bell pepper plants. Journal of Plant Nutrition 26: 1367–82.

Marcussi, F.F.N., Villas Bôas, R.L. 2000. Análise de crescimento e marcha de absorção de um híbrido de pimentão sob condições de cultivo protegido e fertirrigação. Relatório final- FAPESP. p. 1–40.

Mgbeze, G. C., Omodamwen. 2011. Nutrient uptake in pepper (*Capsicum annuum* L.) grown under salt stress. Journal of Agriculture and Biological Sciences. 2: 99–107.

Mass, E.V., Hoffman, G.J. 1977. Crop salt tolerance - Current assessment. Journal Irrigation and Drenage Division 103: 115–34.

Medeiros, J.F. 1998. “Manejo da água de irrigação salina em estufa cultivada com pimentão” Tese Escola Superior de Agricultura “Luiz de Queiróz”- USP – Piracicaba.

Panelo, M. 1995. Adaptabilidad de cultivares de pimiento a condiciones de cultivo protegido. Horticultura Brasilia. 13: 101–103.

Santiago, C.L., Goyal, M.R. 1985. Nutrient uptake undo solute movement in drip irrigated summer bell peppers. Journal of Agricultural Plant Research. 69: 63–68.

Santos, R.F. 2001. “Híbrido de pimentão cultivados em ambiente protegido e convencional fertirrigado com doses de N+K e avaliação da distribuição da evaporação”, Tese, Faculdade de Ciências Agronômicas – Unesp - Botucatu.

Santos, R.V., Muruoka, T. 1997. Interações salinidade e fertilidade do solo. In: Gheyi, H.R., Queiroz, J.E., Medeiros, J.M. (Eds.), Manejo e controle da salinidade na agricultura. UFPB, Campina Grande, pp. 289–315.

Silva, E.F.F. 2002. “Manejo da fertirrigação e controle da salinidade na cultura do pimentão utilizando extratores de solução do solo” Tese, Escola Superior de Agricultura “Luiz de Queiróz”- USP – Piracicaba.

Teodoro, R.E.F. 1986. “Efeito da irrigação no crescimento e produção do pimentão (*Capsicum annum* L.) conduzido em casa de vegetação e em condições de campo”. Dissertação, Escola Superior de Agricultura “Luiz de Queiroz”- USP – Piracicaba.

Tivelli, S.W. 1999. “Sistemas de cultivo na cultura do pimentão vermelho (*Capsicum annum* L.) em ambiente protegido”, tese apresentada a Faculdade de Ciências Agronômicas – Unesp – Botucatu.

Villas Bôas, R.L. 2000. Efeitos de doses de nitrogênio aplicado de forma convencional através da fertirrigação da cultura do pimentão. Horticultura Brasileira, 18: 801–801.

Villas Bôas, R.L. 2001. Doses de nitrogênio para o pimentão aplicadas de forma convencional e através da fertirrigação, tese (para obtenção do título de livre-docente) Faculdade de Ciências Agronômicas – Unesp – Botucatu.