Development and mineral nutrition of gerbera plants as a function of electrical conductivity [1]

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ABSTRACT

The control of substrate salinity is important for agricultural crops and, among the methods used, is the management of electrical conductivity of the substrate solution, which can be used as an indirect measure of the amount of salts and nutrients available or not for the plants. The objective of this study was to assess the effect of EC levels on the development, concentration and accumulation of nutrients in potted (1.3 L) gerbera (*Gerbera jamesonii*). The study was conducted in a greenhouse in a randomized block design, with five treatments (EC of 1.0, 2.0, 3.0, 4.0 and 5.0 dS m^{-1}) and four replications. The quadratic function of the applied EC was obtained for leaf number and diameter, and the linear function, for inflorescence diameter. The nutrients in plant tissue increased linearly with the increasing level of EC, except for potassium and sulfur. The decreasing order for macronutrient levels was K>N>Ca>P>Mg>S, indicating the importance of potassium. Production parameters were little affected by the concentration of the nutrient solution. Therefore, it can be concluded that, with the increase in nutrients as a function of EC elevation, a luxury uptake can occur, with no representative on qualitative aspects.

Keywords: *Gerbera jamesonii*, nutritional assessment, extractant solution, substrate solution.

RESUMO

Desenvolvimento e nutrição mineral de plantas de gérbera em função da condutividade elétrica

O controle da salinidade do substrato é importante para as culturas comerciais agrícolas e dentre os métodos empregados, destaca-se o manejo da condutividade elétrica da solução do substrato, que pode ser utilizado como uma medida indireta da quantidade de sais, nutrientes ou não, disponíveis às plantas. O objetivo foi avaliar o efeito de níveis de CE no desenvolvimento, no teor e acúmulo de macronutrientes na parte aérea de gérbera (*Gerbera jamesonii*), em vaso (1,3 L). O estudo foi realizado em cultivo protegido e o delineamento foi em blocos casualizados, com cinco tratamentos (CE de 1,0; 2,0; 3,0; 4,0 e 5,0 dS m^{-1}) e quatro repetições. Resposta quadrática em função da CE aplicada foi obtida para o número de folhas e diâmetro de planta, e linear, para o diâmetro de inflorescência. Os nutrientes no tecido vegetal apresentaram comportamento linear crescente com o aumento do nível de CE, exceto para o potássio e enxofre. A ordem decrescente dos teores dos macronutrientes foi de K>N>Ca>P>Mg>S, reforçando a importância do potássio para a cultura. Os parâmetros de produção foram pouco afetados pela concentração da solução nutritiva. Desse modo, pode-se inferir que, mesmo com o aumento dos nutrientes em função da elevação da CE, pode ocorrer uma absorção de luxo sem representatividade nos aspectos qualitativos.

Palavras-chave: *Gerbera jamesonii*, avaliação nutricional, extrator de solução, solução do substrato.

1. INTRODUCTION

Gerbera (*Gerbera jamesonii* L.) is a species of the Asteraceae family, native to southern Africa, and its flower can be can be marketed in pots or cut (INFOAGRO, 2005). This crop is an interesting option for the professional specialized in flower production, due to its constant expansion in the market (BALL, 2009).

The control of substrate salinity is important for agricultural crops and, among the methods used, is the management of electrical conductivity of the substrate solution, which can be used as an indirect measure of the amount of salts and nutrients available or not for the plants. Therefore, Mota et al. (2006) suggest substrate solution sampling with the use of extractant solution, thus allowing the determination of electrical conductivity and pH values, enabling knowledge of the nutritional status before the onset of deficiency or toxicity symptoms.

The levels and accumulation of nutrients in the plant tissue, as well as growth parameters, range in vegetative and reproductive periods, among cultivars and nutrient solutions. It is necessary for gerbera that cultivars receive different management, favoring their genetic potential (LUDWIG et al., 2008). Many researchers believe that this plant has an average macronutrient requirement, and they recommend proportions and amounts of fertilizers similar to those used for the chrysanthemum crop (ROJERS and TJIA, 1990).

Studies on electrical conductivity in this species are scarce. Paradiso et al. (2003) worked with levels of electrical conductivity and gerbera cultivars "Brittani" and "Golden Serena", and found that 2.4 dS m^{-1} provided nearly five more flowers than plants grown with 1.6 dS m^{-1}, also showing a higher fresh matter, inflorescence diameter, and stem diameter and length. Zheng et al. (2004) studied lower electrical conductivities (0.2; 0.5; 1.0 and 1.7 dS m^{-1}), and observed no difference in leaf area for cultivar "Shogun".

Considering the quantitative and qualitative importance of fertilization for gerbera, the objective of this study was to assess the effect of electrical conductivity on the development, level and accumulation of macronutrients in the shoots of potted gerbera plants.

2. MATERIAL AND METHODS

The study was conducted in a protected environment, with a total area of 168 m^2 (7.0 x 24.0 m) and 2.6 m height, in the Department of Natural Resources/Soil Science, at the Faculty of Agricultural Sciences of UNESP, located in Botucatu, São Paulo, from October to December 2005. The environment presents a roof arch, with 150-μm transparent plastic, sides with a white screen and reinforced concrete skirting. Light intensity (lux) was kept in the range between 40,000 and 45,000 lux, with the management of a thermo-reflective mesh. The average temperature was 23.7° C and the average relative humidity was 67%.

The experiment was conducted in a randomized block design, using five levels of electrical conductivity (EC) as treatments: 1.0; 2.0; 3.0; 4.0 and 5.0 dS m^{-1} and four replications.

 "Cherry" (cherry color with a dark center) gerbera seedlings were obtained from a specialized company, planted in plastic pots with a volume of 1.3 liters and acclimated for 30 days, with no spacing. The experiment was initiated after the pots were arranged according to the final spacing (30 x 30 cm), and the data were reported in days after spacing (DAE). The substrate consisted of a mixture of 30% red soil and 70% fine pine bark, with the following chemical characteristics: EC$_{1:5}$ 0.56 dS m^{-1} and pH$_{1:5}$ 6.62, quantified according to Brasil (2007).

In order to keep the treatments with constant electrical conductivities, the salt concentration of the substrate solution, which was removed using extractant solution twice a week, was monitored. The extractors were made with a PVC pipe and a porous ceramic capsule at its end, and installed at a depth of 9.5 cm. The substrate solution was suctioned using the methodology proposed by Mota et al. (2011).

Calcium nitrate, potassium nitrate, ammonium sulfate, magnesium sulfate, ammonium monophosphate, Ca + micronutrients (B 0.25%, Ca EDTA 2.57%, Cu EDTA 0.53%, Fe EDTA 2.10%, Fe DTPA 1.74%, Mn EDTA 2.57%, Mo 0.13% and Zn EDTA 0.53%) and iron (4.8% Fe chelate o-o EDDHA) were used as nutrient sources.

The solution at 1.0 dS m^{-1} EC had the following composition, in mg L^{-1}: 82.88 N-NO$_3^-$; 25.62 N-NH$_4^+$; 48.3K; 28.98 P; 80.56 Ca; 5.04 Mg; 22.00 S in the vegetative phase and 75.56 N-NO$_3^-$; 4.92 N-NH$_4^+$; 212.72 K; 11.5 P; 16.18 Mg; 19.78 S in the reproductive phase. For other treatments, nutrients were balanced at the same proportion.

Irrigation control was performed according to the maximum retention capacity. Four tensiometers equipped with a mercury manometer were installed in each treatment at a depth of 9.5 cm, in order to monitor irrigation. Therefore, irrigation was performed whenever water tension in the substrate reached 0.015 MPa.

The number of leaves per plant was recorded weekly, at 19, 26 and 33 DAE. The end of the cycle was determined as a function of the marketing point, characterized by the opening of two rows of stamens in the inflorescences (LIN and FRENCH, 1985), which occurred at 33 DAE.

In the marketing point, the determination of the distance between the ends of the leaf surface in the pot was performed, in two opposite measures, perpendicular to each other, designated leaf surface diameter, measured with a graduated ruler (cm). The average number of gerbera inflorescences was recorded per pot. The average diameter of inflorescences was obtained by making two extreme measures of the inflorescence surface, perpendicular to each other, in mm. The shoot dry matter was obtained after drying the material in a greenhouse with a circulation system and air exchange at a temperature of 65 °C, until a constant mass was obtained. The same material was subjected to determination of levels of macronutrients (N, P, K, Ca, Mg and S), according to the methodology described by Malavolta et al. (1997). The accumulation was calculated by the product of dry matter and content of nutrients. Evaluations were made in one plant per plot.

From the production parameters, the average correlations and average EC obtained using the extractant solution during the cultivation cycle were determined. The effects of the treatments were subjected to regression analysis. The linear and quadratic models were chosen and tested, based on the significance of the regression coefficients at 1% (**) and 5% (*) probability by the F test and on the largest value of the coefficient of determination (R^2).

3. RESULTS AND DISCUSSION

The number of leaves showed quadratic behavior at 19 and 26 DAE, and linear at 33 DAE (Table 1). The total amounts were lower than those obtained by Ludwig et al. (2010) with the same cultivar (27 leaves), due to the reduction in the cycle of this experiment in 25 days. The lower number of cycle days is probably related to the higher average temperature of approximately 4°C. The negative correlation coefficient of the average number of leaves and EC (r: -0.85) confirmed the reduction in the number of leaves with EC elevation (Table 2). Elevated EC levels can result in an undesirable accumulation of nutrients in the root environment with a salt effect (SONNEVELD, 2000).

Table 1. Average number of leaves (NF), leaf surface diameter (DSF), shoot dry matter (FS), number of inflorescences (NI) and diameter of inflorescences (DI) of gerbera per pot, according to the treatment at the end of the crop cycle.

EC (dS m^{-1})	NF			DSF (cm)	FS (g)	NI	DI (mm)
	DAS						
	19	26	33				
1.0	10.0	13.0	19.0	38.9	11.5	2.0	92.0
2.0	14.0	16.0	21.0	40.8	12.6	1.0	93.4
3.0	16.0	18.0	19.0	38.1	12.9	2.0	100.7
4.0	14.0	15.0	18.0	36.6	11.8	3.0	91.3
5.0	10.0	12.0	15.0	38.9	11.5	1.0	110.9
F	NS	NS	NS	NS	NS	NS	L**
Regression	$y = 2.8 + 8.57x - 1.43x^2$ (R^2= 0.99*)	$y = 7.2 + 6.99x -1.21x^2$ (R^2 = 0.94**)	$y = 21.7 -1.1x$ (R^2 = 0.63**)	NS	NS	NS	$y = 86.95 + 3.56x$ (R^2 = 0.46*)

NS: not significant at 5% probability, L: linear effect, **: significance at 1% probability. DAE: Days after spacing)

The leaf surface diameter was not significantly affected by EC (Table 1), as a measure that would indicate larger leaves. The values were higher than those obtained by Ludwig et al. (2010), with 35.0 cm, both for the same cultivar.

No significant effect was observed between treatments for dry matter (Table 1). This parameter was mainly affected by the number of leaves, due to the correlation coefficient of 0.61 between them (Table 2).

The number of inflorescences was not significantly altered by the concentration of the nutrient solution (Table 1). However, if the market requirement is considered, with at least two open buds (LUDWIG et al., 2010), the plants conducted at EC 2.0 and 5.0 dS m^{-1}, were not appropriate.

EC levels only influenced inflorescence diameter, despite the low coefficient of determination. The plants treated with EC 5.0 dS m^{-1} developed inflorescences with a diameter of 110.9 mm. This result may be related to the number of inflorescences, which was, on average, one flower per plant, providing a further development (Table 2). According with Ludwig at al. (2010), the number of inflorescence is not the main factor in the decision of the gerbera customer in its buying, but the its diameter.

Table 2. Correlation coefficient between the parameters evaluated and average EC, measured with the use of extractant solution during the crop cycle.

	Number of leaves	Leaf surface diameter	Dry matter	Number of inflorescences	Diameter of inflorescences	Average EC
Number of leaves	-	0.40	0.61	0.05	-0.76	-0.85
Leaf surface diameter	-	-	0.23	-0.87	0.08	-0.38
Dry matter	-	-	-	-0.11	-0.10	-0.19
Number of inflorescences	-	-	-	-	-0.55	-0.09
Diameter of inflorescences	-	-	-	-	-	0.78

Aesthetic quality characteristics range between types of ornamental plant and potted flower, and it is important to consider the formation of foliage and inflorescences (LUDWIG et al., 2011). Accordingly, the assembly formed by the leaf surface diameter and the number of inflorescences adds value to the final product, being of utmost importance in regard to quality.

The nutrients in the plant tissue showed a significant increasing linear behavior at 1%, with an increase in EC level (Figure 1), except for potassium (K) and sulfur (S).
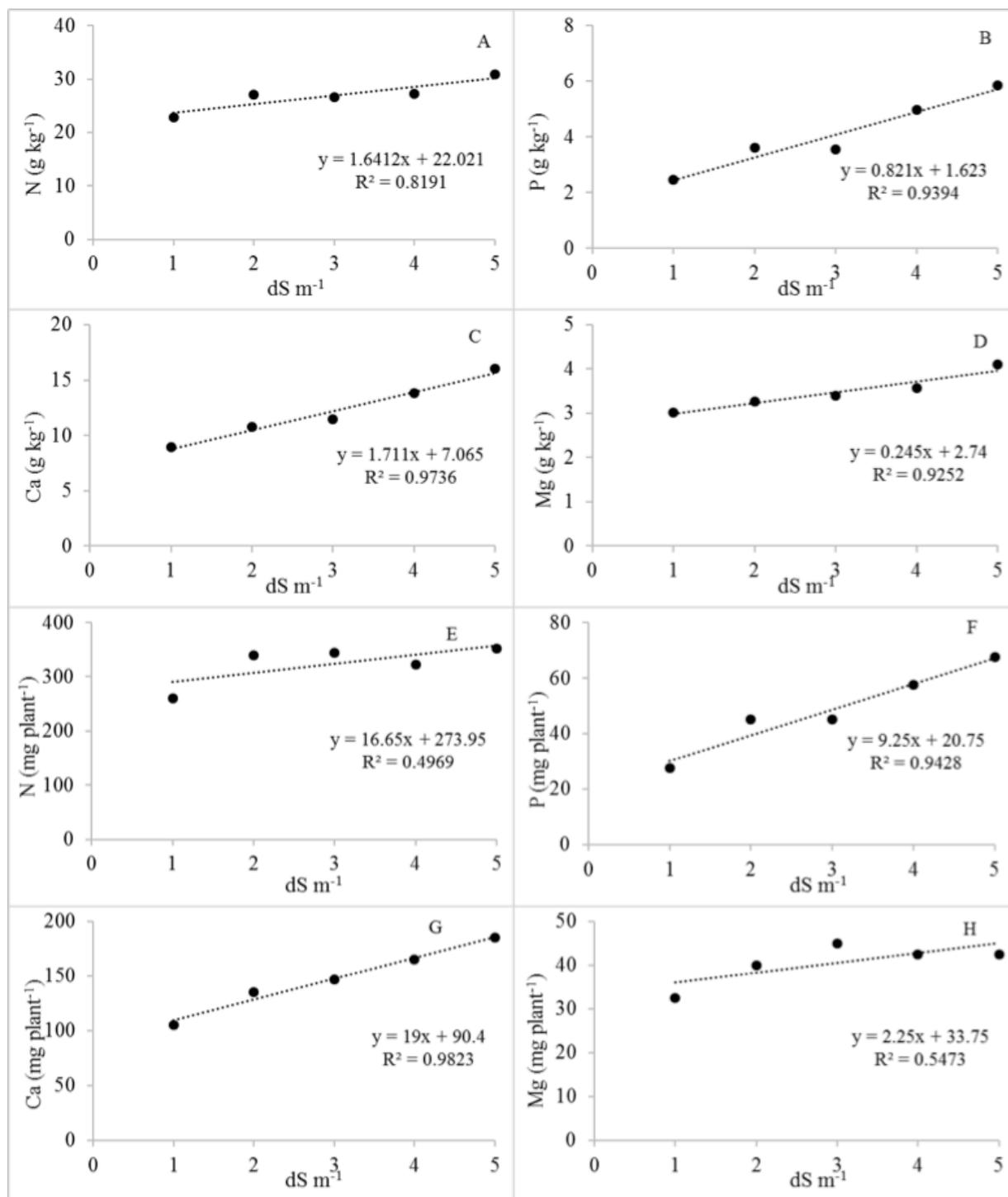
Figure 1. Content and accumulation of N (A and E), P (B and F), Ca (C and G) and Mg (D and H) in gerbera tissues at different electrical conductivities of the nutrient solution.

The highest content of nitrogen (N) was found in the treatment with 5.0 dS m^{-1} (Figure 1), which is consistent with the value established as the optimum upper limit for the development of gerbera (27.0 to 31.0 g kg^{-1}) by Mercurio (2002). On the other hand, the lowest value, 23.0 g kg^{-1}, obtained for an EC of 1.0 dS m^{-1}, is below, possibly justifying the lighter green color of plant leaves from this treatment. The accumulation values of this nutrient had the same increasing linear tendency (Figure 1).

The contents of phosphorus (P) ranged from 2.5 to 5.9 g kg^{-1}, from the lowest to the highest EC, with the same increasing trend towards accumulation (Figure 1) and, therefore, only the levels obtained with the ECs from 1.0 to 3.0 dS m^{-1} are within the range proposed by Mercurio (2002), from 1.9 to 3.5 g kg^{-1}. However, Jones Jr. et al. (1996) determined levels between 2.0 and 5.0 g kg^{-1} as an optimum range. The range obtained by Ludwig et al. (2008) was between 1.6 and 2.4 g kg^{-1} for the same cultivar, subjected to

two solutions (0.92 and 1.76 dS m^{-1} in the vegetative phase and 1.07 and 2.04 dS m^{-1} in the reproductive phase).

For the content and accumulation of K, there was no significant difference between treatments, with an average content of 46.0 g kg^{-1}. The recorded levels were higher than those mentioned by Mercurio (2002), who established an ideal range from 30.6 to 36.4 g kg^{-1}. When the plants were conducted with the highest electrical conductivities, the contents of K fall within the range proposed by Jones Jr. et al. (1996), from 25.0 to 45.0 g kg^{-1}. Several studies report that K is the nutrient which is most absorbed by gerbera (SAVVAS and GIZAS, 2002; LUDWIG et al., 2008), confirming the results presented in this study.

Despite the increase in content and accumulation of calcium (Ca) with the increase in EC (Figure 1), the levels were below the range (16.6 to 21.8 g kg^{-1}) proposed by Mercurio (2002). However, considering the recommendation (10.0 to 35.0 g kg^{-1} Ca) made by Jones Jr. et al. (1996), only an EC of 1.0 dS m^{-1} did not meet this requirement. Ludwig et al. (2008) also found Ca in the same range (9.0 and 10.0 g kg^{-1} Ca) obtained in this experiment.

The contents of magnesium (Mg) in gerbera shoots ranged from 3.0 to 4.1 g kg^{-1} (Figure 1), having been adjusted (3.0 to 4.8 g kg^{-1} Mg; 2 0 to 7.0 g kg^{-1} Mg by Mercurio (2002) and Jones Jr. et al. (1996), respectively). These values were, however, higher than those obtained (2.9 g kg^{-1} Mg) by Ludwig et al. (2008) with the same cultivar. Both the content and accumulation of this nutrient, showed an increasing linear behavior as a function of the applied EC (Figure 1).

There was no effect of treatments on sulfur contents in gerbera plants, with average contents of 1.3 g kg^{-1}, lower than recommended (2.5 to 7.0 g kg^{-1} S) by Jones Jr. et al. (1996). However, Ludwig et al. (2008) found average values of 1.8 g kg^{-1} for the same cultivar, suggesting that the optimal level of this nutrient is dependent on cultivar. One of the great difficulties in considering one content as ideal, is that the reference values in the literature are based on gerbera cutting plants, besides the differentiated demand among cultivars.

The order of absorption of nutrients followed the sequence K>N>Ca>P>Mg>S, which is partially in agreement with Ludwig et al. (2008), who found a higher accumulation for Mg in relation to P.

4. CONCLUSION

Production parameters were little affected by the concentration of the nutrient solution. Therefore, it can be concluded that, with the increase in nutrients as a function of EC elevation, a luxury uptake can occur, with no representative on qualitative aspects.

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