Australian Journal of Basic and Applied Sciences
2018 December; 12(12): pages 32-35
DOI: 10.22587/ajbas.2018.12.12.5
Original paper
Journal home page: www.ajbasweb.com
AENSI Publications

Electrical Conductivity in Nutritive Solution and Influence on Hydroponic Production in Lettuce Culture (*Lactuca sativa* L.)

Victor Hugo Moraes[1], Pedro Rogerio. Giongo[2], Matheus Vinicius Abadia Ventura[1], Angelina Maria Marcomini Giongo[2], Thomas Jefferson Cavalcante[1], Bruno Henrique Tondato Arantes[1], Estevam Matheus Costa[1]

[1]*Postgraduate Program in Agrarian Sciences - Agronomy, Goiano Federal Institute, Rio Verde, Brazil*
[2]*School of Agricultural Engineering, State University of Goias, Santa Helena de Goias, Brazil*

Correspondence Author: Victor Hugo Moraes, *Postgraduate Program in Agrarian Sciences - Agronomy, Goiano Federal Institute, Rio Verde, Brazil*

Received date: 15 November 2018, **Accepted date:** 20 December 2018, **Online date:** 31 December 2018

Abstract

Food production at scale needed to meet today's need is a matter of enormous concern to the world. Hydroponics is a technique that has caused a growing world interest. The experiment was conducted in May and June 2013 under greenhouse conditions at the State University of Goias, Santa Helena de Goias campus. The experimental design was a randomized block design in a 3x7 factorial scheme with three replications, the first one factor: three commercial lettuce cultivars (American GL, Rafaela-Americana and Simpson Black Seed) and the second factor: seven EC concentrations, being 0.92, 2.00, 2.22, 2.99, 4.03, 4.41 and 5.02 µS.cm-1. The cultivars Americana GL, Rafaela Americana and Simpson Black Seed in the hydroponic cultivation system had their productive characteristics influenced by the EC concentrations between 0.92 and 5.02 µS.cm-1. The cultivars Rafaela A and Simpson BS show better performances in the ECs from 0.92 to 2.99 µS.cm-1. There is a propensity for better performances for the American GL cultivar, for the range of 2 to 4 µS.cm-1. The increase of the EC concentrations decreased the dry mass of the plants and the root length of the tested cultivars.

Key words: hydroponics, *Lactuca sativa* L., protected environment, nutritious

INTRODUCTION

Food production at scale needed to meet today's need is a matter of enormous concern to the world. In this sense, it is necessary to analyze cultivation techniques that overcome this limitation as a result of the constant increase in the need for food, and it is important to seek cultivation techniques that provide high productivity coupled with production quality, short cycle, agricultural inputs and labor (PAULUS et al., 2010; PAULUS et al., 2012; SILVA et al., 2015)

Vertical hydroponics is a technique that has caused a growing worldwide interest, being an alternative of cultivation with nutritive solution in the presence or absence of natural or artificial substrates that have developed in laboratories (ALBERONI, 1998), which may influence nutritional and water availability (SILVA et al., 2015). This technique has proven to suppress current production demands, and in Brazil, its use has expanded mainly in lettuce cultivation, as a result of this system presenting advantages, due to the size of the crop.

The lettuce (*Lactuca sativa* L.) is a vegetable of world production, mainly by means of salads, originating in the Mediterranean, being one of the first vegetables cultivated by the man in the world. Currently in Brazil, it is used throughout the national territory, both in soil and in hydroponic systems, being the main culture used in hydroponics in the country (SOARES, 2002; LOPES et al. 2005).

In Brazil, lettuce is a more important vegetable produced in hydroponic system NFT (laminar flow of nutrients), hydroponic culture being an alternative to conventional cultivation, with advantages for the consumer, the producer and the environment (PAULUS et al., 2012). Its cultivation is very vulnerable to adverse climatic conditions such as rain, hail, frost, temperature and also the presence of pathogens in the soil, due to its size, which can favor the production of plants of low sanitary and hygienic quality, causing concern for being an *in natura* food being one of the advantages of hydroponics, the absence of these pathogens (REZENDE et al., 2007).

To obtain the maximum efficiency of the culture, several proposals of nutritive solutions appeared, with the most varied formulations (FURLANI, 1995; BERNARDES, 1997; MARTINEZ, 1997; SOARES, 2002; SILVA et al., 2015). In most cases, it is sought to maintain both the concentration of nutrients offered to the plants and the electrical conductivity of the nutrient solution, in order to monitor the amount of soluble salts, avoiding the salinization of the nutrient solution (BECKMANN-CAVALCANTE et al., 2010).

The nutrient solution used in lettuce cultivation, the electrical conductivity varies between 1,6 and 1,8 dS m^{-1} (SOARES, 2002) until 2,5 dS m^{-1} (CASTELLANE & ARAÚJO, 1995), being in hydroponics it is usual to use the electric conductivity (EC) as an indirect means of evaluation (HELBEL JUNIOR et al., 2008). However, it is important to highlight the importance of quantifying the best EC in each Brazilian region due to the environmental factors, cultivars most used, varieties consumed and regionally adapted, among others, that mistakenly employed can limit all productivity.

The objective of this work was to evaluate the influence of the electrical conductivity on the agronomic characteristics and yield of three lettuce varieties, in order to obtain the ideal electrical conductivity in the nutrient solution.

.

Citation: Victor Hugo Moraes, *et al.*, Electrical Conductivity in Nutritive Solution and Influence on Hydroponic Production in Lettuce Culture (*Lactuca sativa* L.). Australian Journal of Basic and Applied Sciences, 12(12): 32-35. DOI: 10.22587/ajbas.2018.12.12.5

MATERIALS AND METHODS

The experiment was carried out in May and June of 2013 under greenhouse conditions in the State University of Goias, Santa Helena de Goias campus, in the city of Santa Helena de Goias – GO, Brazil. The experimental design was a randomized block design in a 3x7 factorial scheme, with three replicates, using the hydroponic cultivation NFT, the first factor being three commercial lettuce cultivars (American Great Lakes, Rafaela-Americana and Simpson Black Seed) and the second factor: seven EC concentrations, where 0.92, 2.00, 2.22, 2.99, 4.03, 4.41 and 5.02 $\mu S.cm^{-1}$.

Regarding the planting of seedlings, the seeds were placed to germinate in trays with styrofoam cells with dimensions of 2x2x2 cm. Plantmax commercial substrate was used to fill cells. Soon after the placement of the seeds, they were moistened daily with distilled water until the germination aiming at the uniform growth.

The seedlings were transferred to nutrient solution, with EC established in each of the treatments. As for the nutrient solutions used in the irrigation of the plants, seven stock solutions were used, which were diluted in distilled water, in order to obtain the ECs of 1.0; 1.5; 2.0; 2.5; 3.0; 3.5 and 4.0 dS m^{-1}.

After adjusting the ECs with the dilution with distilled water, the micronutrient stock solutions were incorporated according to the commercial recommendations, obtaining the concentrations of iron (Fe): 5 mg L^{-1}, manganese (Mn): 0.5 mg L^{-1}, zinc (Zn): 0.05 mg L^{-1}, boron (B): 0.5 mg L^{-1}, molybdenum (Mo): 0.01 mg L^{-1} and copper (Cu): 0.02 mg L^{-1}. According to the recommendations of lettuce cultivation, the nutrient solutions were monitored for a pH between 5.5 and 6.5, using the Digital pHmeter, the range being that the plants have greater availability of nutrients (CARMELLO & ROSSI, 1997; KOPP et al., 2000). ECs were also monitored by a portable conductivity meter, often to ensure the results of each treatment.

The plants were harvested when they reached adult size, in order to standardize growth time in established EC. The following were evaluated: the number of leaves, where the total number of leaves in each plant were counted; length of leaves and roots, which were measured using ruler; the fresh mass of the air part and root, where the plants were weighed with a precision scale; and the dry mass of the air part and root, and the same plants that were weighed were used to obtain the weight of the fresh mass and were then conditioned in a greenhouse with forced air circulation at 65^{o}C for 72 hours for drying, those which achieve constant weight. The data were submitted to analysis of variance by the test of probability (Test F) of 5% to verify the effects of significance and afterwards, submitted to the Tukey test.

RESULTS AND DISCUSSION

Table 1 presents the analysis of variance information for the variables: leaf number (LN), mass of the air part (FM), fresh root mass (MFR), mean leaf length (CMF).

Table 1. Analysis of variance for the leaf number (LN), green mass of the air part (GMA), fresh root mass (FRM), mean leaf length (MLL) evaluated in a hydroponic system in Santa Helena de Goias, GO.

FV	Test F			
	Leaf number (LN)	Green mass of the air part (GMA)	Fresh root mass (FRM)	Mean leaf length (MLL)
ECs	0.7217	0.6461	0.3875	0.0237*
Cultivars	0.0005*	0.2182	0.7703	0.3201
ECs * Cultivars	0.0363*	0.0007*	0.0016*	0.3199
LDS (0.05)	20.47	40.68	41.48	20.44

* Significant by F test at 5% probability level.

The LN did not show a significant difference for the EC factor, and there was a significant effect between the lettuce cultivars and the interaction of the factors. The interaction effect between was significant, so that the cultivars is influenced by the concentrations, corroborating with the results also obtained by Guazzelli (2000) in hydroponic lettuce cultivation.

It was not shown a significant difference for the GMA of the plants in the factor EC and Cultivars, and in the interaction between the effects of the ECs x Cultivars it was possible to observe difference, providing a dependence between the factors. According Barbieri et al. (2010) explains that EC increase improves nutrient availability and absorption for lettuce.

Significant effect was observed for the FRM only in the interaction of the factors, but not for the isolated factors. Batista et al. (2012) obtained significant effects for different ECs, where EC is determinant in the accumulation of FRM. There was a significant effect on the MLL, only for the EC factor, not differing for the factor Cultivars isolated and the interaction between the factors, and no work was found and/or published for this variable.

Table 2 presents the data of the analysis of variance for mean root length (MRL), stem diameter (SD), dry air weight (DAW) and root dry mass (RDM).

Table 2. Analysis of variance for mean root length (MRL), stem diameter (SD), dry air weight (DAW) and root dry mass (RDM) evaluated in hydroponic system in Santa Helena de Goias, GO.

FV	Test F			
	Mean root length (MRL)	Stem diameter (SD)	Dry air weight (DAW)	Root dry mass (RDM)
ECs	0.0001*	0.8336	0.6461	0.3615
Cultivars	0.0008*	0.3058	0.2182	0.3005
ECs * Cultivars	0.5008	0.0073*	0.0007*	0.0014*
LDS (0.05)	18.77	20.47	40.68	40.99

* Significant by F test at 5% probability level.

Significant effect on MRL was observed only between the interaction of the factors. These results corroborate with those obtained by Helbel Junior (2004), which evaluated different compositions and flow rates of the nutrient solution in lettuce cultivars in the hydroponic system.

There was a significant effect on SD only in the interaction and no effect was observed on the isolated form factors. For the SD variable, the interaction effect agrees to observe both low and high EC, the effect is the same in cultivars. Different from that observed by Martinez (1997), which observed increase in SD with the increase of ECs when submitted to lettuce cultivars in a hydroponic system.

It was observed that the interaction effect between the factors being significant, so that the cultivars depended on the concentrations for the DAW and RDM parameters. In Table 3, it is seen that only in the concentrations of EC: 0.92 and 2.99 $\mu S.cm^{-1}$, there was a significant effect, while in the other EC, it did not influence the cultivars, for the LN. It does not show a better trend or some ideal EC value for one or more of the cultivars evaluated. This effect was verified by Barbieri et al. (2010), which evaluated lettuces submitted to concentrations of 1 to 2 $\mu S.cm^{-1}$.

Table 3. Analysis of the averages for leaf number (LN) for 7 ECs and 3 lettuce cultivars, evaluated in a hydroponics system in Santa Helena de Goias, GO.

Citation: Victor Hugo Moraes, *et al.*, Electrical Conductivity in Nutritive Solution and Influence on Hydroponic Production in Lettuce Culture (*Lactuca sativa* L.). Australian Journal of Basic and Applied Sciences, 12(12): 32-35. DOI: 10.22587/ajbas.2018.12.12.5

	ECs*						
Cultivars	0,92	2,00	2,22	2,99	4,03	4,41	5,02
Americana GL	6.33 a	8.67 a	7.33 a	6.50 a	9.00 a	8.83 a	7.83 a
Rafaela- A	10.67 b	9.17 a	8.00 a	6.83 a	7.33 a	6.83 a	7.33 a
Simpson BS	10. 67 b	9.17 a	8.33 a	12.5 b	9.67 a	9.83 a	9.33 a
LSD (0.05)	20.47						

* Means followed by the same lowercase letter in the column are equal to each other, by the Tukey test at the 5% probability level.

There is no influence of increase or decrease of LN for the increase of EC in the varieties evaluated. All ECs submitted to lettuce cultivars presented similar LN by Tavares & Junqueira (1999) and Guazzelli (2000), who observed that the plant increased with the increase in EC of the nutrient solution.
There was a significant effect among cultivars only at EC: 0.92, 2.22 and 2.99 $\mu S.cm^{-1}$ (Table 4). No statistically significant difference was observed for other ECs. In the ECs 0.92 and 2.99 $\mu S.cm^{-1}$, it was found that the Rafaela A and Simpson BS varieties had a significant effect that exceeded the Americana GL varitie, while in the EC 2.22 $\mu S.cm^{-1}$ the significant effect was higher for the variety Americana GL and Rafaela A, compared to cultivar Simpson BS. The lowest values of EC had significant effects, while the increase of EC did not differ in the behavior of lettuce cultivars. These behaviors differed from those observed by Pinto et al. (2004), which obtained significant differences of GMA for lettuce in low and high ECs of the nutrient solution.

Table 4. Analysis of the averages for green mass of the air part (GMA) for 7 ECs and 3 lettuce cultivars, evaluated in a hydroponics system in Santa Helena de Goias, GO.

	ECs*						
Cultivars	0.92	2.00	2.22	2.99	4.03	4.41	5.02
Americana GL	6.44 a	22.40 a	28.51 ab	15.28 a	40.52 a	40.14 a	30.58 a
Rafaela-A	37.31 b	40.07 a	50.57 b	25.61 ab	26.91 a	21.32 a	21.44 a
Simpson BS	28.25 ab	24.03 a	18.11 a	45.56 ab	23.16 a	27.84 a	19.24 a
LSD (0.05)	40.68						

* Means followed by the same lowercase letter in the column are equal to each other, by the Tukey test at the 5% probability level.

There is no increase or decrease in EC growth in any of the varieties, where the varieties have random effects when sent to different EC between 0.92 the 5.02 $\mu S.cm^{-1}$. These results differ from those obtained by Silva et al. (2000), observed a decrease in the relative production of lettuce, which was affected by the saline effect of the soil.
According Barbieri et al. (2010), the highest accumulation of green mass of the shoot for lettuce is 1.8 $\mu S.cm^{-1}$, and that this effect was not observed in this research for any of the evaluated varieties. Pinto et al. (2004) observed that the increase in EC of the nutrient solution promoted an increase in leaf area production, reaching the maximum production in the EC of 1.80 $dS.m^{-1}$, and that EC values higher than these, promoted a reduction in leaf mass, not corroborating the information obtained in this work for the three evaluated cultivars.
Significant effect was shown for FRM only at concentrations of 0.92 and 2.99 $\mu S.cm^{-1}$ (Table 5). The cultivar Rafaela A. stands out in low ECs, in the parameter FRM.

Table 5. Analysis of the averages for fresh root mass (FRM) for 7 ECs and 3 lettuce cultivars, evaluated in a hydroponics system in Santa Helena de Goias, GO.

	ECs*						
Cultivars	0,92	2,00	2,22	2,99	4,03	4,41	5,02
Americana GL	2,48 a	7,85 a	9,72 a	5,15 a	13,85 a	12,99 a	10,25 a
Rafaela-A	10,63 b	13,30 a	11,48 a	7,07 a	8,32 a	6,68 a	6,26 a
Simpson BS	8,83 a b	10,18 a	8,11 a	12,50 b	8,39 a	12,99 a	5,55 a
LSD (0.05)	41.48						

* Means followed by the same lowercase letter in the column are equal to each other, by the Tukey test at the 5% probability level.

The FRM was higher when submitted under EC reductions for the cultivar Rafaela A. In EC, the superiority is of the cultivar Simpson BS, however in high ECs the superiority is evident in the cultivar Americana GL.

According to Table 6, there was a significant effect among the varieties only in the concentrations of EC: 0.92 and 2.99 $\mu S.cm^{-1}$. In the two EC groups, the varieties Rafaela A. and Simpson BS had a superior effect, compared to the cultivar Americana GL.

Table 6. Analysis of the averages for mean root length (MRL) for 7 ECs and 3 lettuce cultivars, evaluated in a hydroponics system in Santa Helena de Goias, GO.

	ECs*						
Cultivars	0.92	2.00	2.22	2.99	4.03	4.41	5.02
Americana GL	13.50 a	26.33 a	26.92 a	22.67 a	25.50 a	20.17 a	17.00 a
Rafaela-A	24.00 b	28.33 a	26.42 a	23.33 ab	24.00 a	23.67 a	16.00 a
Simpson BS	25.17 b	29.92 a	31.58 a	32.00 b	25.83 a	27.83 a	20.00 a
LSD (0.05)	18.77						

* Means followed by the same lowercase letter in the column are equal to each other, by the Tukey test at the 5% probability level.

The range of ECs between 2 and 2.22 and 4 to 5 $\mu S.cm^{-1}$ showed high effects for all cultivars tested, with EC of 0.92 and 2.99 decreasing mean MRL values. Table 7 shows that in the low and medium ECs (0.92 and 2.99), shoot dry mass was higher in the cultivars Rafaela A. and Simpson BS, while in the other cultivars no significant effect was observed and, therefore, effect of ECs on any lettuce cultivar tested in the hydroponic system.

Table 7. Analysis of the averages for dry air weight (DAW) for 7 ECs and 3 lettuce cultivars, evaluated in a hydroponics system in Santa Helena de Goias, GO.

	ECs*						
Cultivars	0.92	2.00	2.22	2.99	4.03	4.41	5.02
Americana GL	0.54 a	1.88 a	2.39 a	1.28 a	3.40 a	3.37 a	2.56 a
Rafaela-A	3.18 b	3.41 a	4.30 b	2.18 ab	2.29 a	1.81 a	1.83 a
Simpson Black Seed	2.11 ab	1.80 a	1.35 a	3.41 b	1.74 a	2.09 a	1.44 a
LSD (0.05)	40.68						

* Means followed by the same lowercase letter in the column are equal to each other, by the Tukey test at the 5% probability level.

No significant difference in shoot dry matter mass was observed for all cultivars submitted to Americana GL (0.92 to 5.02 $\mu S.cm^{-1}$). Therefore, at any concentration, the cultivar will show the same, being that lower and medium EC for the cultivars Rafaela-A and Simpsons Black Seed, showed evident differences. These results differ from those obtained by Beltrão et al. (1997), in which the authors affirm that the increase in conductivity leads to a decrease in dry matter production, as well as productivity.

Citation: Victor Hugo Moraes, *et al.*, Electrical Conductivity in Nutritive Solution and Influence on Hydroponic Production in Lettuce Culture (*Lactuca sativa* L.). Australian Journal of Basic and Applied Sciences, 12(12): 32-35. DOI: 10.22587/ajbas.2018.12.12.5

Although there was no significant effect among the factors in isolation, the cultivars Rafaela A. and Simpson BS showed to be superior in EC lowering, when there was an antagonistic behavior when submitted to high EC, for the same lettuce cultivars.

CONCLUSIONS

The cultivars Americana GL, Rafaela Americana and Simpson Black Seed in the hydroponic cultivation system had their productive characteristics influenced by the EC concentrations between 0.92 and 5.02 $\mu S.cm^{-1}$.

The cultivars Rafaela A and Simpson BS show better performances in the ECs from 0.92 to 2.99 $\mu S.cm^{-1}$.

There is a propensity for better performances for the Americana GL cultivar, for the range of 2 to 4 μS.cm-1. The increase of the EC concentrations decreased the dry mass of the plants and the root length of the tested cultivars.

ACKNOWLEDGEMENT

The authors thank the PIBIC / UEG (Institutional Program for Scientific Initiation Scholarships) for the scientific grant awarded to the first author, and the UEG / Campus Santa Helena de Goiás.

REFERENCES

Alberoni, R. B. 1998. Hidroponia - como instalar e manejar o plantio de hortaliças dispensando o uso do solo. São Paulo: Nobel.

Barbieri, E., MELO, D., Andrade, L. F., Pereira, E. W. L., & Cometti, N. N. 2010. Condutividade elétrica ideal para o cultivo hidropônico de alface em ambiente tropical. Horticultura Brasileira, 28(2):S303-S308.

Batista, M. A. V.; Vieria, L. A.; Sousa, J. P.; Freitas, J. D. B.; Bezerra Neto, F. 2012. Efeito de diferentes fontes de adubação sobre a produção de alface no município de Iguatu-CE. Revista Caatinga, 25(3):8-11.

Beckmann-Cavalcante, M. Z., Pivetta, K. F. L., Cavalcante, Í. H. L., Cavalcante, L. F., Bellingieri, P. A., & Campos, M. C. C. 2010. Electrical conductivity of nutrient solution for chrysanthemum pot cultivation. Revista Brasileira de Ciência do Solo, 34(3):747-756.

Beltrão, J., Trindade, D., & Correia, P. J. 1997. Lettuce yield response to salinity of sprinkle irrigation water. Acta Horticulturae, 449:623-627.

Bernardes, L. J. L. 1997. Hidroponia da alface - uma história de sucesso. Charqueada: Estação experimental de hidroponia "Alface & Cia".

Carmello, Q. A. C. & Rossi, F. 1997. Hidroponia - solução nutritiva. Manual n.111. Viçosa, Centro de Produções Técnicas.

Castellane, P. D.; Araújo, J. A. C. 1995. Cultivo sem solo: – hidroponia. 4. ed. Jaboticabal: FUNEP/UNESP.

Furlani, P. R. 1995. Cultivo de alface pela técnica de hidroponia NFT. Campinas: Instituto Agronômico de Campinas (Documentos IAC, 55).

Guazzelli, E. S. 2000. Cultivo de alface (*Lactuca sativa* L.) em sistema hidropônico NFT. (Doctoral thesis - Universidade Federal do Ceará).

Helbel Júnior, C. 2004. Produção de alface hidropônica em função da composição da solução nutritiva e vazões. (Masters dissertation - Universidade Estadual de Maringá).

Helbel Junior, C., Rezende, R., Freitas, P. S. L. D., Gonçalves, A. C. A., & Frizzone, J. A. 2008. Effect of electric conductivity, ionic concentration and flow of nutrient solutions in the production of hidroponic lettuce. Ciência e Agrotecnologia, 32(4):1142-1147.

Kopp, L. M., Schunemann, A. P. P., Neto, J. B., De Souza Lemos, C. A., Simonetti, R. B., & Da Silva, É. S. B. 2000. Avaliação de seis cultivares de alface sob duas soluções nutritivas em sistema de cultivo hidropônico. Revista da FZVA, 7/8(1):7-16.

Lopes, J. C.; Ribeiro, L. G.; Araújo, M. G.; Beraldo, M. R. B. S. 2005. Produção de alface com doses de lodo de esgoto. Horticultura Brasileira, 23(1), 143-147.

Martinez, H. E. P. 1997. Formulações de soluções nutritivas para cultivos hidropônicos comerciais. Jaboticabal: FUNEP.

Paulus, D.; Dourado Neto, D.; Frizzone, J. A.; Soares, T. M. 2010. Produção e indicadores fisiológicos de alface sob hidroponia com água salina. Horticultura Brasileira, 28(1):29-35.

Paulus, D.; Dourado Neto, D.; Paulus, E. 2012. Análise sensorial, teores de nitrato e de nutrientes de alface cultivada em hidroponia sob águas salinas. Horticultura Brasileira, 30(1):18-25.

Pinto, F. A.; Feitosa, V. S.; Souza, V. S.; Soares, I. 2004. Avaliação de diferentes condutividades elétricas da solução nutritiva no cultivo de alface em substrato. Revista Ciência Agronômica, 35:165-170.

Rezende, R., Junior, C. H., De Freitas, P. S. L., Gonçalves, A. C. A., Dallacort, R., & Frizzone, J. A. 2007. Diferentes soluções nutritivas aplicadas em duas vazoes na produçao hidropônica da cultura da alface. IRRIGA, 12(3):354-363.

Silva, Ê. F. F.; Duarte, S. N.; Ferreira, Y. R. P.; Miranda, J. H. 2000. Tolerância da cultura de alface à salinidade. Horticultura Brasileira, 18:788-789.

Silva, M. G., Soares, T. M., De Souza Oliveira, I., Da Silva Santos, J. C., Pinho, J. S., & De Freitas, F. T. 2015. O. Produção de coentro em hidroponia NFT com o uso de águas salobras para reposição do consumo evapotranspirado. Revista Brasileira de Agricultura Irrigada-RBAI, 9(4):246-258.

Soares, I. 2002. Alface; cultivo hidropônico. Fortaleza: Editora UFC.

Tavares, H. L.; Junqueira, A. M. R. 1999. Produção hidropônica de alface cv. Verônica em diferentes substratos. Horticultura Brasileira, 17(3):240-243.