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Original Paper

Arugula crop cultivation in hydroponic system in the Agreste region of Paraiba State – Brazil, using different plant densities and nutrient solution concentrations

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Abstract

Hydroponics has been gaining increasing interest because of its contribution to reducing environmental impacts through minimal use of water and fertilizers. The objective of this work was to evaluate the production of arugula cultivars in the harsh region of Paraíba , under hydroponic system and under different plant densities and nutrient solution concentration. The research was carried out in Campus II of the UEPB (Lagoa Seca-PB) and followed a randomized block design in the 2 x 2 x 2 factorial scheme, two cultivars of cultivated arugula (Cultivated, Broad Leaf), two plant densities (10 and 15 plants per phenolic foam) and two concentrations of the nutrient solution (100 and 120%) with four replicates. The hydroponic system used was the NFT. For the nutrient solution, a commercial fertilizer produced for leafy olives (Compound + Calcium + Iron) was used. The seedlings were produced in phenolic foam (2 x 2 x 2 cm). The cultivation beds had 8 channels (4.5 m each), where each one represented one block. The spacing used was 0.25m x 0.25m between plants and between rows, respectively. The data of the variables were submitted to analysis of variance by the F test at 5% probability and the Tukey test to compare the means. At 41 days after sowing, the growth parameters were analyzed, where it was verified that the two arugula cultivars can be cultivated satisfactorily, in a hydroponic system, under the conditions of the harsh region of Paraíba without increasing the recommended dose of the nutrient solution and plant population.

Key-words: NFT, *Eruca sativa,* Agreste

Introduction

The demand and the requirements of domestic and international markets of high-quality products cultivated in a sustainable manner have made vegetable growers seek the adoption of new production technologies without losing sight of economic viability (Zang et al., 2015). Several studies with the objective of evaluating the economic Viability of the intercalary system of plants were carried out in previous years, showing promising results (Cecílio Filho et al., 2008; Silva et al., 2008; Costa et al., 2008; Barros Júnior, 1998), and other studies have shown that this is not a problem. However, information on hydroponics has attracted increasing interest worldwide because of its contribution to reducing environmental impacts through minimum use of fertilizers and available water. According to Luz et al. (2011), this technique is the cultivation of plants without soil, where the roots receive a balanced nutrient solution that contains water and all the essential nutrients to the development of the plant, which facilitates a more

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adequate control of the nutrition of the greenery produced.

Given that many cultures are grown in this system, arugula (Eruca sativa Miller) belonging to the *Brassicaceae* family, is produced between the main broadleaf via hydroponics (Genuncio et al., 2011). This is due to its easy adaptation to the system, in which it has revealed high yield and reductions of cycle in relation to the cultivation in the soil. Despite this information, producers and researchers in the Northeast region, especially the mesoregion in the harsh region of Paraíba, still need a greater number of data on hydroponics technologies, since there are few reports in the literature about the behavior of this crop in different cultivars, nutritional levels, climate, availability of water, etc. Genuncio et al. (2011) reports that the factors to be managed are oxygen concentration, electrical conductivity (EC), pH, temperature, as well as the time and flow rate of the solution available to the roots of plants during its entire cycle (Furlani et al., 1999). Values close to 12 mg L^{-1} of O_2; 6.0 of pH and 27 ºC of solution temperature are the parameters used by producers in the different regions of Brazil. On the other hand, there is a wide variation in the EC, the time and the flow of irrigation to be established in hydroponics. For lettuce, which corresponds to the reference culture in this system, EC values may range from 0.9 to 2.5 m^S cm^{-1} (Furlani et al., 1999; Schmidt et al., 2001; Rodrigues, 2002).

Thus, this work may contribute significantly to the production of information about the performance of the cultivars tested and open a range of possibilities for research with other crops in this municipality and surrounding regions. The objective of this work was to evaluate the production of arugula cultivars in the harsh region of Paraíba, under hydroponic system, in different plant densities and nutrient solution concentrations.

Material and Methods

The research was carried out between 04/19/2016 and 05/30/2016, at Campus II of the State University of Paraíba (UEPB), located in the municipality of Lagoa Seca - PB (Latitude 7 º 09 '17,88 "S, Longitude 35 º 52 '16,65 "W and altitude of 653 m). According to data from the Meteorological Station of the State Agricultural Research Company of Paraíba S. (EMEPA), located in Lagoa Seca - PB, the average annual rainfall is 950 mm, mean annual evapotranspiration of 1,100 mm and average daily sunshine of 7; 7; 7; 6; 6; 5; 5; 7; 7; 8; 9 and 8 o'clock in the months of January, February, March, April, May, June, July, August, September, October, November and December, respectively. The experimental design was a randomized block design in the 2 x 2 x 2 factorial scheme, with two treatments of curly arugula (Cultivated Arugula and Broad Leaf), two plant densities (10 plants per phenolic foam and 15 plants per phenolic foam) and two concentrations of the nutrient solution (100 and 120%), with four replicates. A chapel-type greenhouse (11 m long, 8.5 m wide, 3.0 m high) and east-west orientation was used to implement the hydroponic cultivation. The environment was protected in the ceiling by transparent fiberglass tiles, and on the sides, by shading screens with 50% light retention. The hydroponic system used was the NFT (Nutrient Laminar Flow Technique), where the nutrient solution was distributed in the culture channels by a circulating electro pump. The nutrient solution of the hydroponic system was formulated using the Hidrogood Fert® product for hardwood crops (Compound + Calcium + Iron), whose nutrient values, in percentage, are as follows: N (10), P_20_5 (9), K_2O), Mg (3.3), S (4.3), B (0.06), Cu (0.01), Mo (0.07), Mn (0.05), Zn. The dilution concentrations recommended by the manufacturer for 1000 L of the solution were: 750 g of Compound + 550 g of Calcium Nitrate + 30 g of EDDHMA Fe, to obtain an electrical conductivity (EC) = 1,7 mS. When necessary, the EC was corrected for solution according to the manufacturer's recommendation: at each decrease of 0.3 mS per 1000 L, 132 g of Compound + 97 g of Calcium Nitrate + 6 g of EDDHMA Fe were used.

The seedlings were produced in phenolic foam cubes (2 x 2 x 2 cm) previously thoroughly washed with running water to relieve the environment of contaminating substances and to regulate their pH, according to the manufacturer's recommendations. In each foam cube, 0.5 cm deep conical holes were opened, where the seeds were deposited in a number determined for each treatment already described in the experimental design. After sowing, they were accommodated in the maternity ward, in an environment protected from sunlight, where they remained for a week. During this period, the phenolic foam plates were initially irrigated with the solution in 50% of their total strength, aiming adaptation of the seedlings to the solution and avoiding possible osmotic shock. After one week, the seedlings were transferred to the nursery bench, with nutrient solution diluted to 75%, where they also remained for a week. Later, the seedlings were transferred to the final stands, where they were irrigated with nutrient solution at 100 and 120% of their concentration, according to the treatment of the experimental design. The monitoring of the need for solution replacement was checked daily with a ruler graduated in centimeters and adapted to the nutrient solution reservoir. For the formulation of the initial and replacement solution, rainwater was collected from the roof of the greenhouse. When necessary, the pH and EC of the nutrient solution were corrected. The pH was monitored daily with the aid of a portable digital peg diameter and maintained between 5.5 and 6.5. The electrical conductivity of the solution was monitored by portable conductivity meter and maintained at ± 1.7 mS.

The final cultivation beds were composed of 8 channels made of polypropylene, trapezoidal (4.5 m long each), where each bench represented an experimental block. The two canals at the end of the benches served as a border and their plants were not used in the evaluations of the studied variables. These cultivation channels were supported by four support points, installed at an average height of 0.85 m, with slope of 6.0%. The spacing used was 0.25m x 0.25m between plants and between rows, respectively. For the storage of the nutrient solution, a reservoir with a capacity of 250 liters was used for each bench, but they worked with only 60% of their storage capacity. In each bench the control of the circulation and aeration of the nutrient solution was carried out with the aid of a motor pump with a power of 23 W, installed in a drowned form and driven by an analog timer that carried out the circulation of the solution during 15 minutes and 15 minute intervals off.

During the night, the timer would trigger the pumping for 15 minutes at 3-hour intervals on all benches. Data collection of arugula cultivars was performed at 41 days after sowing, where the following variables were analyzed: number of germinated plants, leaf green weight, number of leaves, productivity, leaf area, leaf area index, leaf area ratio, dry leaf weight, root dry weight, stem dry weight and stem diameter. The aerial part and the roots were separately transferred to a greenhouse with air circulation at 65 °C to obtain the respective dried phytomass of each part, and then weighed on a precision scale (0,01 g). The data of the variables were submitted to analysis of variance by the F test at 5% of probability. The Tukey test was also performed to compare the means obtained for each variable. Statistical analysis was performed in the SISVAR program (Ferreira, 2014).

Results and discussion

The analysis of variance (Table 1) showed an isolated effect of the treatments for the number of germinated plants (NGP), leaf area (LA), dry leaf weight (DLW), stem diameter (S.D). However, there was an interaction effect of the treatments for productivity (PROD), leaf area matter (LAM) and leaf dry weight (LDW), and it was indicated if these interactions were to be deployed instead of analyzing their isolated effects.

Table 1. Summary of variance analysis performed on arugula cultivars, produced under hydroponic system, under different seed densities and nutrient solution concentration.

FV	GL	Variables											
		NP	PVF	NF	PROD	AF	IAF	AFE	TAF	PSF	PSR	PSC	DC
Grow crop	1	1,12	2,39	0,60	270785	118833	0,39	473646	256	0,00	0,0	0,0	0,25*
Density	1	98,0**	53,7	0,04	2373225	21640	0,07	78568	2381*	0,04	0,0*	0,0	0,17
Solution	1	2,00	0,47	1,12	1957488	36199	0,12	60959	378,2	0,06*	0,0**	0,0	1,1**
Block	3	2,58	1,18	0,15	1335972	17848	0,05	125997	29,28	0,00	0,0	0,0	0,01
C*D	1	1,12	0,79	0,18	4235374	6351,0	0,02	307614	841,9*	0,16**	0,0	0,0	0,00
C*S	1	3,12	0,26	0,50	12343692*	480,00	0,00	271687	375,9	0,06*	0,0	0,0	0,11
D*S	1	4,50	3,39	0,00	464,000	143361	0,47	377332	592,5	0,024	0,0	0,0	0,15
C*D*S	1	1,12	0,01	0,04	298904	46399	0,15	428798	507,8	0,04	0,0	0,0	0,08
Error	21	3,58	2,31	0,74	2476884	47508	0,15	165733	181,1	0,01	0,0	0,0	0,04
CV (%)	-	19,9	24,1	10,8	15,43	47,70	47,7	55,88	30,23	18,25	23,9	25,7	7,85

*, ** - Significant by the Tukey test at 5 and 1%, respectively.

Analyzing the isolated effect of the treatments (Table 2), it was verified that the number of germinated plants presented better response when the planting density of 15 seeds per bucket of phenolic foam was used. On the other hand, green leaf weight, dry root weight and stem diameter presented the highest averages when 10 seeds per cubic of phenolic foam were used, indicating that there was a greater competition between plants when grown at higher planting density.

Table 2. Number of plants (NP), green leaf weight (PVF), root dry weight (PSR), stem dry weight (PSC) and stem diameter (DC) of ariculture cultivars produced under hydroponics, under different seed densities and nutrient solution concentration.

Assessments	Cultivars		Density		Solution	
	Cultivars	wide leaf	10 seeds	15 seeds	100%	120%
NP (ud.cubo^{-1})	9,68	9,31	7,75 b	11,25 a	9,75	9,25
PVF (g.plants^{-1})	6,04	6,59	7,61 a	5,02 b	6,19	6,43
PSR (g.plants^{-1})	0,06	0,06	0,071 a	0,057 b	0,072 a	0,056 b
PSC (g.plants^{-1})	0,03	0,03	0,03	0,03	0,042 a	0,034 b
DC (cm.plants^{-1})	2,72 a	2,54 b	2,71 a	2,56 b	2,82 a	2,45 b

Lowercase letters in the lines do not differ by Tukey test.

Contrary results were obtained by Batista et al. (2016) in two consecutive field crops, when it was verified that the maximum yields of green and dry mass of arugula, cv. Cultivated, were resulting from planting with twice the recommended density for this crop. These opposite results may have occurred due to the fact that in this experiment the arugula cultivars were submitted to the conditions of higher temperatures, which are more recurrent in the harsh region of Paraíba, and this implied in greater competition among the plants when submitted to the plant densities. Allied to this fact, Furlani et al. (2009) recommend decreasing the amount of salts in the preparation of the nutrient solution for the regions of high temperatures, which may lead to better development of the plants.

Concerning the concentration of the nutrient solution, the dry root weight, dry stem weight and stem diameter showed the highest averages when the solution was used with only 100% of its indicated concentration for leafy olives. The diameter of the stem showed an isolated effect of the cultivars, with the cultivar Cultivated with the highest average in this variable. However, Luz et al. (2011) evaluated in hydroponic system, different concentrations of the nutrient solution (50%, 75%, 100% and 125%), and it was verified and found that arugula did not suffer from these treatments in its development. Similar results were also observed by Luz et al. (2009), because the different concentrations of the nutrient solution did not cause significant effects for all the evaluated characteristics of the three species studied (smooth chicory, curly chicory and dandelions).

The consequences of the density interaction of seeds x cultivars, as well as the solution interaction x cultivars are shown in Table 3 where it can be seen, in the first interaction, the dry weight of the leaves showed a higher average (0.763 g.plant^{-1}) when used to cultivate broadleaf with 10 seeds per cube density of phenolic foam.

These results do not corroborate with those found by Lima et al. (2013), when evaluating the production of arugula, cv. Cultivated, in a consortium system, because they verified the highest yields of green mass when they increased the recommended plant density by 50%. Concerning the second interaction, there was a decrease in this parameter only in the cultivar Broad Leaf (0.563 g.plant^{-1}) when it was produced with the solution at 120% of its indicated concentration.

Table 3. Dry leaf weight (PSF) of arugula cultivars produced under hydroponic system, under different seed densities and nutrient solution concentration.

Assessments	PSF (g.plants^{-1})		PSF (g.plants^{-1})	
	10 seeds	15 seeds	100%	120%
Cultivars	0,621 B a	0,694 A a	0,658 A a	0,658 A a
Wides leaf	0,763 A a	0,545 B b	0,745 A a	0,563 A b

Capital letters in the column and lowercase in the row do not differ by the Tuckey test

On the other hand, Cometti et al. (2008) found that the dry mass of the lettuce leaves did not change when the authors used the nutrient solution at 50 and 100% doses. However, those lower doses (25 and 12.5%) provided the lowest averages of this variable.

In the productivity of arugula (Table 4), it was also verified the solution interaction x cultivars, with behavior similar to the dry weight of the leaf, that is, the productivity decreased when the cultivar "Broad Leaf" was used in the solution at 120% of its concentration (9,425.68 kg ha-1). This indicates that the increase in the concentration of the solution caused a toxic effect in this cultivar, since in regions of high temperatures it is indicated the decrease of the concentrations of the nutrient solution for a better development of the plants grown in hydroponic system (Furlani et al., 1999; Schmidt et al., 2001; Furlani et al., 2009).

Table 4. Productivity (PROD) and foliar area rate (TAF) of arugula cultivars produced in a hydroponic system, under different seed densities and nutrient solution concentration.

Assessments	PROD (kg ha^{-1})		TAF (%)	
	100%	120%	10 seeds	15 seeds
Cultivars	9736,37 A a	10483,86 A a	55,45 A a	27,93 B b
Wides leaf	11162,50 A a	9425,68 A b	50,25 A a	43,86 A a

Capital letters in the column and lowercase in the row do not differ from one another by the Tuckey test.

On the other hand, Steiner et al. (2011) and Benett et al. (2015) found increases in arugula production as nitrogen fertilization rates increased.

Regarding the leaf area rate, it was verified that the increase of planting density, in cv. Cultivated, it provided the worst result, probably due to the competition between plants for space, light and nutrients. Still, the increase in the number of plants per area provided higher yields in the beet and lettuce crops in the NFT hydroponic system in Mococa-SP (Caroli et al., 2014). Thus, it is necessary to study the most varied production systems, as well as their adaptation and indication to each region of this country, since the climatic conditions of the same are so different.

Conclusion

The two cultivars of Arugula (Cultivated and Broad Leaf) can be cultivated satisfactorily in a hydroponic system under the conditions of the harsh region of Paraíba without increasing the recommended dose of the nutrient solution and the number of seeds by phenolic foam.

Conflict of interest: All authors declare no conflict of interest.

References

Barros Júnior, A.P.; Alves Rezende, B.L.; Filho, A.B.C.; de Queiros Pôrto, D.R.; da Silva, G.S.; Geraldo Martins, M.I.E. 2009. Análise econômica da alface americana em monocultura e consorciada com pepino japonês em ambiente protegido. Bioscience Journal 25(4): 82-89

Batista, T.M.V.; Neto, F.B.; Silva, I.N.; da Silva, M.L.; de Oliveira, E.Q.; Barros Júnior, A.P. 2016. Agronomic efficiency of the intercropping of arugula with carrot under different population combinations. Revista Caatinga, 29(1): 76-84

Bezerra Neto, F.; Porto, V.C.N.; Gomes, E.G; Cecílio Filho, A.B; Moreira, N.J. 2012. Assessment of agroeconomic indices in polycultures of lettuce, rocket and carrot through uni and multivariate approaches in semi-arid

Brazil. Ecological Indicators, New York, 14(1): 11-17
Benett, K.S.S.; Benett, C.G.S.; Santos, G.G. dos; Costa, E. 2015. Effects of hydrogel and nitrogen fertilization on the production of arugula in successive crops. African Journal of Agricultural Research 10(26): 2601-2607
Borges, C.T.; Deuner, C.; Rigo, G.A.; Oliveira, S.; Moraes, D.M. 2014. O estresse salino afeta a qualidade fisiológica de sementes de rúcula. Enciclopédia Biosfera 10(19): 1049-1057
Calori, A.H.; Factor, T.L.; Lima Júnior, S.; Moraes, L.A.S.; Barbosa, P.J.R.; Tivelli, S.W.; Purquerio, L.F.V. 2014. Electrical conductivity and plant spacing on baby leaf table beet and lettuce production. Horticultura Brasileira 32: 426-433
Cecílio Filho, A.B. et al. 2008. Viabilidade produtiva e econômica do consórcio entre chicória e rúcula em função da época de plantio. Horticultura Brasileira 26(3): 316-320
Cecílio Filho, A.B. et a. 2015. Indices of bio-agroeconomic efficiency in intercropping systems of cucumber and lettuce in greenhouse. Australian Journal of Crop Science 9(12): 1154-1164
Cometti, N.N.; Matias, G.C.S.; Zonta, E.; Mary, W.; Fernandes, M. 2008. Efeito da concentração da solução nutritiva no crescimento da alface em cultivo hidropônico–sistema NFT. Horticultura Brasileira 26: 252-257
Costa, C.C. et al. 2008. Viabilidade econômica dos consórcios de grupos de alface com rúcula, em duas épocas de cultivo. Bioscience Journal 24(2): 27-42
Ferreira, D.F. 2014. Sisvar: A guide for its bootstrap procedures in multiple comparisons. Ciência e Agrotecnologia 38:109-112
Filgueira, F.A.R. 2008. Novo manual de olericultura: Agrotecnologia moderna na produção e comercialização de hortaliças. Viçosa-MG: UFV, 421p
Furlani, P.R. et al. 2009. Cultivo Hidropônico de Plantas: Parte 2 - Solução nutritiva
Lima, J.S.; Chaves, A.P.; Neto, F.B.; Santos, E.C.; Rodrigues, G.S. de O. 2013. Produtividade da cenoura, coentro e rúcula em função de densidades populacionais. Revista Verde 8(1): 110-116
Lima, V.I.A. de; Lima, J.S.S. de; Neto, F.B.; Santos, E.C. dos; Rodrigues, G.A.S. de O.; Paula, V.F.S. de. 2014. Viabilidade agroeconômica do cultivo consorciado de coentro, alface e rúcula sob diferentes arranjos espaciais. Enciclopédia Biosfera 10(18): 3060-3065
Luciene, L.; Fernandes, A. A.; Schmildt, E.R.; Almeida, C.P.DE; Pinto, M. L. P. B. 2017. Desempenho da alface e da rúcula em diferentes concentrações de ferro na solução nutritiva. Revista de Ciências Agraria 60(1): 45-52
Luz, J.M.Q.; Costa, C.C.; Guerra, G.M.P.; Silva, M. A.D.; Haber, L.L. 2011. Efeito da variação da solução nutritiva no cultivo hidropônico de rúcula. Revista Verde de Agroecologia e Desenvolvimento Sustentável 6(3): 76 -82
Luz, J. M. Q.; Silva, M. A. D. da; Haber, L. L.; Pirolla, A.C.; Doro, L.F.A. 2009. Cultivo hidropônico de chicórias lisa e crespa e almeirão em diferentes concentrações de solução nutritiva. Revista Ciência Agronômica 40(4): 610-616
SIlva, G.S. et al. 2008. Viabilidade econômica do cultivo da alface crespa em monocultura e em consórcio com pepino. Ciência e Agrotecnologia, 32(5): 1516-1523
Zang, Y. et al. 2015. Row ratios of intercropping maize and soybean can affect agronomic efficiency of the system and subsequent wheat. PlosOne 10(6): 1-16

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