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Revista Facultad Nacional de Agronomía

UNIVERSIDAD NACIONAL DE COLOMBIA

Behavior of three lettuce cultivars in a hydroponic system

Comportamiento de tres cultivares de lechuga en un sistema hidropónico

doi: 10.15446/rfnam.v73n2.75423

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ABSTRACT

The cultivation of lettuce in a hydroponic system is an alternative to optimize the production. Lettuce is an important food, being one of the most consumed vegetables in Brazil. The objective of this study was to evaluate the agronomic behavior of commercial cultivars of lettuce under a single nutritive solution in a hydroponic system. The experiment was carried out under greenhouse conditions. The experimental design was completely randomized, with five replicates. The treatments were composed of commercial lettuce cultivars (Americana Great Lakes, Rafaela-Americana, and Simpson Black Seed). At the time of harvest, the following parameters were evaluated: number of leaves, length of leaves and roots, fresh mass of shoot and root, and stem diameter. The collected data were submitted to an ANOVA. The cv. Rafaela-Americana presented higher leaf length. The evaluated cultivars did not present significant differences in the number of leaves, aerial green mass, green root mass, root length, and stem diameter. The cultivars showed similar variations in the number of leaves, aerial green mass, green root mass, root length, and stem diameter. The cultivar Rafaela-Americana presented a superior performance in the development of leaf length regarding the other cultivars.

Keywords:
Cultivars
Lactuca sativa L.
Nutrient solution
Protected cultivation

RESUMEN

El cultivo de lechuga en un sistema hidropónico es una alternativa para optimizar su producción. La lechuga es un alimento importante, ya que es una de las verduras más consumidas en Brasil. El objetivo de este estudio fue evaluar el comportamiento agronómico de cultivares comerciales de lechuga bajo una única solución nutritiva en un sistema hidropónico. El experimento se realizó en condiciones de invernadero. El diseño experimental fue completamente al azar con cinco repeticiones. Los tratamientos estaban compuestos por cultivares comerciales de lechuga (Americana Great Lakes, Rafaela-Americana y Simpson Black Seed). Al momento de la cosecha se evaluaron los siguientes parámetros: número de hojas, longitud de hojas y raíces, masa fresca de brotes y raíces, y diámetro del tallo. Los datos recopilados fueron sometidos a una ANAVA. El cv. Rafaela-Americana presentó mayor longitud de hoja. Los cultivares evaluados no presentaron diferencias significativas en el número de hojas, masa verde aérea, masa de raíz verde, longitud de raíz y diámetro del tallo. Los cultivares mostraron variaciones similares en el número de hojas, masa verde aérea, masa de raíz verde, longitud de raíz y diámetro del tallo. El cultivar Rafaela-Americana presentó un desempeño superior en el desarrollo de la longitud de la hoja con respecto a los otros cultivares.

Palabras clave:
Cultivares
Lactuca sativa L.
Solución nutritiva
Cultivos protegidos

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Received: October 8, 2018; Accepted: February 4, 2020
Rev. Fac. Nac. Agron. Medellín 73(2): 9165-9170. 2020

ISSN 0304-2847 / e-ISSN 2248-7026

Brazil is considered one of the world's largest producers and consumers of vegetables (Santi *et al*., 2010; Pantoja Neto *et al*., 2016; França *et al*., 2017). Its consumption has increased, not only for the healthier and natural food trending, but mainly by the population increase. The consumption market of vegetables has become much more demanding, requiring quality, and supply throughout the year; therefore, production systems have become increasingly specialized (Favarato *et al*., 2017).

In this context, it is necessary to seek better cultivation techniques that overcome this limitation and accomplish with the demand for food. It is important to study cultivation techniques to favor high productivity, coupled with the quality of production and a guaranteed supply of food (Santos *et al*., 2011; Moreira *et al*., 2014). One of the techniques that have aroused a growing interest worldwide is hydroponics. This technique consists in the use of the nutrient solution, in the presence or absence of natural or artificial substrates, providing mineral elements essential to the development of the plant, being applied mainly in vegetable protected crops (Delaide *et al.* 2016; Pantoja Neto *et al*., 2016). It meets the current requirements of production, and in Brazil, its use has expanded, mainly, in the cultivation of lettuce (*Lactuca sativa* L.) because this system presents advantages regarding soil cultivations.

Lettuce (*Lactuca sativa*) is a vegetable belonging to the Asteraceae family, which originated in Europe-Mediterranean. It has high socio-economic importance, contributing to the generation of jobs, as well as food and human health, being a source of many vitamins and minerals and dietary fibers (Ohse *et al*., 2001; Silva *et al*., 2017) and one of the vegetables most commercialized in Brazil (Queiroz *et al*., 2017).

Lettuce stands out in the hydroponic crops of the national scenario, being responsible for up to 80% of this type of production (Alves *et al*., 2011). Hydroponic lettuce cultivation presents advantages for the environment, for the product and the consumer, with the generation of quality products, fast cycle, higher production, besides providing less water and agricultural inputs, among others (Paulus *et al*., 2012). Besides, in protected cultivation, hydroponics is a well-adopted system for lettuce production because it is an intensified production system due to the short cycle crop (Santos, 2017).

For the success of hydroponic cultivation, a fundamental aspect is the choice of the nutrient solution, which must be formulated according to the nutritional need of the plant, containing adequate proportions of the essential nutrients for its growth (Schmidt *et al*., 2001). However, in order to be successful in this system, one of the factors to be considered is the choice of the appropriate cultivar, where the resulting productive potential depends on genetic interaction and the environment. In order to obtain better yields, cultivars adapted to the temperature and photoperiod conditions of the production region must be selected, thus achieving better yields (Brzezinski *et al*., 2017). Thus, the present work had as objective to analyze the production of lettuce under a single nutrient solution in a hydroponics system.

MATERIALS AND METHODS

The experiment was carried out at the Universidade Estadual de Goias (State University of Goiás), in the municipality of Santa Helena de Goiás (17°49'33.9" S, 50°36'224.7" W, average elevation of 570 m). According to the classification of Köppen and Geiger (1928), the climate of the region is type Aw (tropical), with a rainy season in summer and dry season in winter, with an annual average rainfall of 1,539 mm, average air temperature of 24.3 °C. The experimental design was randomized in blocks, and the effects between a single nutrient solution and the cultivars (Americana Great Lakes, Rafaela-Americana, Simpson Black Seed) were studied in five replications.

The experiment was conducted in an arbor, semi-detached, 12 m long, 8 m wide, and 4 m right foot and black shading cover (30% interception of light). The seedlings were produced in expanded polyethylene trays with cells of dimensions 2 cm×2 cm×2 cm with a commercial PlantMax® substrate. Seven days after germination, the seedlings roots were washed, removing any excess substrate from the roots and transplants into the hydroponic system. Soon after the transplant, the treatments were started the same day.

The nutrient solution in all treatments was prepared with the same amount of fertilizers, following the recommendation

of Furlani *et al.* (2009) which contained 750 g of Hydro Special Nitrate Hydro, 500 g of Potassium Nitrate, 150 g of monoammonium phosphate (MAP), 400 g Magnesium Sulphate, 0.15 g of Copper Sulphate, 0.5 g of zinc sulfate, 1.5 g of Manganese Sulphate, 1.5 g of boric acid, 0.15 g of sodium molybdate ($Na_2MoO_{4.2}H_2O$), 30 g of Tenso-Fe® (FeEDDHMA-6% Fe) for every 1000 L of water. The pH of the solution was maintained between 5.5 and 6.5.

The system used was NFT (laminar flow of nutrients), in which the nutrient solution was distributed in the cultivation channels, at a flow rate of 3 L min^{-1} (3W power), with a drive frequency programmed to drive the motor pump for 15 and 30 min disconnected in the daytime period (6 h – 19 h) and for 15 min on, at each interval of 2 h at night (19 h - 6 h).

The nutrient solution was conducted by pumping thorough a PVC tubing (commercial diameter 40 mm) from the reservoir to the top of the bed by a programmed digital timer, returning to the reservoir by gravity. The water used to prepare the nutrient solution was drinking water. For storage of the nutrient solution in the amount of 5 L, transparent plastic tanks with a capacity of 5.5 L and coated with aluminum foil were used to minimize the incidence of solar radiation in the reservoirs.

The nutrient solution was used according to commercial recommendations. According to the recommendations of the surface cultivation, the nutritional solutions were monitored to a pH between 5.5 and 6.5, using the digital pH meter, being the plants with greater availability of nutrients (Carmello and Rossi, 1997; Kopp *et al.*, 2000). ECs were also monitored by a portable conductivity meter, usually to guarantee the results of each treatment. The reading of the electrical conductivity and pH was performed daily to keep them in the electrical conductivity ranges of 1.60 dS m^{-1} and pH between 5.5 and 6.5. The working range of pH and electrical conductivity was determined according to the methodology described by Moraes *et al.* (2018), being the best ranges for pH and electrical conductivity for hydroponics lettuce production. The spacing was 0.25 m between lines and 0.25 m between plants. The plants were harvested when they reached their adult size, and the three central plants of each profile were harvested.

Forty days after planting, weights, and measurements of the following parameters were performed:

- Number of leaves: total leaves were counted in each plant.
- Leaf length (LL) and root length (RL): measurements using a ruler.
- Fresh mass of aerial part (FMA) and root (FMR): separated the aerial part of the root of each plant with a cross-section in the stem and weighed on a precision scale.
- Stem diameter (SD): A precision digital caliper measuring the basal part of the plant was used.

The data were submitted to ANOVA, using the F test, and the Tukey test was performed. The results were considered significant when $P<0.05$ and expressed as mean and standard deviation. All statistical analyzes were performed using the Sirvar software (Ferreira, 2019).

RESULTS AND DISCUSSION

There was a significant difference only for the leaf length variable among the three cultivars. The other variables did not present a significant difference (Table 1).

Table 1. *P*-values for the Analysis of Variance (ANOVA) for the leaf number (LN), fresh mass of aerial part (FMA) and fresh mass of roots (FMR), average leaf length (ALL), root length (RL), and stem diameter (SD), obtained from three lettuce cultivars, evaluated in a hydroponic system in Santa Helena de Goiás, GO.

FV	DG[1]	LN	FMA	FMR	ALL	RL	SD
Cultivars	2	0.9563	0.0690	0.1781	0.0001*	0.3929	0.3766
Blocks	4	0.9069	0.4762	0.2523	0.1538	0.3169	0.3838
Error	8						
CV (%)		13.14	27.45	32.37	5.08	13.52	15.74

*Statistically significant by the F test at the 5% probability level.
[1] Degrees of Freedom

According to this study, no significant differences were observed for most of the parameters evaluated, from the aerial part (leaves and stem) and root (root), although only three cultivars were submitted to the hydroponic production system. Andrade *et al.* (2010), when evaluating ten different lettuce cultivars in the hydroponic production system, identified that some do not present differences in fresh mass weight, and for leaves formed four groups, stem three groups and root only two groups. The results obtained by Andrade *et al.* (2010) differ from this research, but also considers that a much higher number of cultivars were evaluated.

Magalhães *et al.* (2010) found significant differences in fresh shoot weight in the seven lettuce cultivars submitted to different concentrations of nutrient solution in a hydroponic system, highlighting that there were only two groups for this variable, differing from the results obtained in this research. They also highlight the same authors as for the Number of leaves of the cultivars. Vitória Verdinha, Regina 579, and Babá of Summer did not differ from each other but were superior to the others evaluated. These results show that the differences in performance for a number of leaves may not be influenced by the nutrient solution in a hydroponic system, depending on the characteristics of each cultivar.

Gualberto *et al.* (2018) observed significant differences in parameters, number of leaves per plant, stem length, fresh mass, and dry mass between the cultivars Crocantejullie and TPC submitted to different cultivation systems. These results differ from this research considering that no differences were identified between the cultivars Americana Great Lakes, Rafaela-Americana, Simpson Black Seed, so it can be affirmed that cultivars can respond differently to cultivation condition.

The Americana Great Lakes and Simpson Black Seed cultivars had better leaf length averages in relation to the cv. Rafaela-Americana (Table 2). There was a significant difference between the varieties for the average length of leaves of plants on the lettuce cultivars so that the cultivars had different behavior (Table 2), only for cv. Rafaela-Americana, there was a superior effect in relation to the cultivars Americana Great Lakes and Simpson Black Seed in this parameter. The length of leaves is one of the most important characteristics since it is the main one observed by the consumers of fresh vegetables.

In leafy vegetables such as lettuce, the number of leaves is an important characteristic for commercialization since most consumers acquire lettuce per unit and not by weight, taking into account the appearance, volume, and the number of leaves per head (Diamante *et al.*, 2013). The average number of leaves of the three cultivars analyzed was very close, and there was no significant difference (Table 2). These results were lower for the cultivar Simpson Black Seed (curly) when compared to the data obtained by Horino *et al.* (1993), which found an average of 27 leaves per plant considering the cultivars Regina 579, Luisa, Vit. Verdinha, Forest, Summer Nanny, Manoa, Saia Véia.

Table 2. Mean leaf number (LN), fresh mass of aerial part (FMA) and root (FMR), average leaf length (ALL), root length (RL), Stem diameter (SD) obtained from three cultivars of lettuce, evaluated in a hydroponic system in Santa Helena de Goiás, Brasil.

Cultivars	LN	FMA(g)	FMR(g)	ALL(cm)*	RL(cm)	SD(mm)
Americana Great Lake	9.40	33.52	6.34	13.42 b	21.60	7.96
Rafaela-Americana	9.20	37.88	7.08	16.88 a	24.44	8.22
Simpson Black Seed	9.20	23.18	4.60	12.98 b	23.38	7.12
Standard deviation	1.22	8.65	1.94	0.73	3.13	1.22

*Statistically significant variable at 5% according to ANOVA and Tukey test.

The average green air mass of the cv. Rafaela-Americana reached a value of 37.88 g and, close to this value, the Americana Great Lake cv. had an air green mass of 33.52 g. However, the Simpson Black Seed cultivar was not successful, with a green sprout weight of only 23.18 g, but no significant differences were observed (Table 2).

These results were inferior to those obtained by Fernandes (2002) working with lettuce to cultivate summer nanny, Grandes Lagos, and Regina in a conventional hydroponic system, that is, these authors with lettuce cultivars that presented greater weight than the cultivars used in this work.

Da Silva *et al.* (2007) when researching four lettuce cultivars in hydroponic systems, they reported that the cultivar Mônica, from the crespa group, presented higher root development in relation to the cultivar Tainá, from the Americana group while the cultivar Regina, of the smooth group, presented a number of leaves per plant.

The cv. Rafaela-Americana obtained greater development of the root system, consequently obtaining root with higher weights in relation to the cultivars Americana Great Lakes and Simpson Black Seed, and the cv. Americana Great Lakes was superior to the cv. Simpson Black Seed, but there were no significant differences between cultivars (Table 2). The average weight of green roots in the cv. Rafaela-Americana was 7.08 g, while the Simpson Black Simpson had an average of 4.60 g per plant evaluated in the hydroponics system.

There was no significant effect on any of the three cultivars in the root length parameter. The cultivars Rafaela-Americana and Simpson Black Seed had the root length numerically superior to cv. Americana Great Lakes. The average root length of the cultivars Rafaela-Americana and Simpson Black Seed was very close, being 24.44 cm and 23.38 cm of the root, respectively. The cv. Americana Great Lake had a lower mean of 21.60 cm of the root (Table 1 and 2).

The diameter of the stem is an important feature for the fast-food industry, and if the stem is thick, it facilitates the manual removal for later slicing (Blind and Filho 2015). There was no significant difference between the stem diameter variable (Table 1 and 2). It is observed that the highest stem diameter average was in the cultivar Rafaela A, reaching a mean of 8.22 mm, followed by the cultivar Americana Great Leak with an average of 7.96 mm. The cultivar Simpson Black Seed showed a mean stem diameter of only 7.12 mm.

Assessing lettuce production in a hydroponic system in northern Minas Gerais, Aquino *et al.* (2017) worked with four curly cultivars (Verônica, Marisa, Cinderela and Roxane), of the smooth type (Summer Babysitter and Regina) and of the American type (Irene) and concluded that the summer nanny cultivar was the most promising. In our study, the most prominent cultivar was cv. Rafaela-Americana, with greater leaf length.

CONCLUSIONS

The cultivars showed no statistical difference in the number of leaves, aerial green mass, green root mass, root length, and stem diameter. The cultivar Rafaela-Americana presented a superior performance in the development of leaf length regarding the other cultivars.

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