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Production of lettuce cultivars in greenhouse in Humaitá, southern Amazonas state

Produção de cultivares de alface em casa de vegetação em Humaitá, sul do estado do Amazonas

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ABSTRACT

Lettuce is the main leafy vegetable commercialized in Brazil and it is cultivated in many different environment conditions and regions. But, under high temperature and high light intensity lettuce plants tend to early flowering, making it difficult to obtain high-quality lettuce harvest. Thus, this study was aimed to evaluate the productive performance of lettuce cultivars in a greenhouse in the municipality of Humaitá, Amazonas state (AM). The cultivars used were Rafaela and Hanson, Veneranda, Mônica SF 31, Simpson, Solaris, Elba, Quatro Estações and Babá de Verão. The lettuce seedlings were transplanted 24 days after sowing into a greenhouse covered by 100 micra polyethylene transparent agrofilm. It was used bed with 33-m-long and 1-m-wide, using 30 cm x 30 cm spacing between plants. The experimental design was randomized complete block with four replications. The parameters evaluated 32 days after transplanting were plant diameter, number of leaves, stem length and shoot dry mass. Cultivars Babá de Verão and Elba presented a better agronomic performance for cultivation in greenhouse in municipality of Humaitá, Amazonas state.

KEYWORDS: development; early bolting; high temperature; *Lactuca sativa* L.

RESUMO

A alface é a principal folhosa comercializada no Brasil, sendo cultivada em muitas regiões e ambientais diferentes. Entretanto, sob altas temperaturas e elevada intensidade luminosa as plantas de alface tendem ao florescimento precoce, dificultando a obtenção de uma colheita de alface de alta qualidade. Assim, no presente estudo objetivou-se avaliar o desempenho produtivo de cultivares de alface em ambiente protegido no município de Humaitá, estado do Amazonas (AM). As cultivares usadas foram Rafaela e Hanson, Veneranda, Mônica SF 31, Simpson, Solaris, Elba, Quatro estações e Baba de Verão. As mudas de alface foram transplantadas 24 dias após a semeadura para casa de vegetação coberta com agrofilme de polietileno transparente de 100 micra. Foi utilizado canteiro com 33 m de comprimento e 1 m de largura, utilizando-se espaçamento de 30 cm x 30 cm entre plantas. O experimento foi conduzido utilizando-se delineamento em blocos completos casualizados com 4 repetições. Os parâmetros avaliados 32 dias após o transplantio foram o diâmetro da planta, número de folhas, comprimento do caule e massa seca da parte aérea. As cultivares Baba de Verão e Elba apresentaram melhor desempenho agronômico para o cultivo protegido no município de Humaitá, estado do Amazonas.

PALAVRAS-CHAVE: desenvolvimento; pendoamento precoce; temperaturas elevadas; *Lactuca sativa* L.

The lettuce crop cycle time and growth varies according to the cultivar and the season, with better development in mild climate conditions (SALA & COSTA 2012, LAFTA et al. 2017, DJIDONOU & LESKOVAR 2019). It achieves optimum growth temperature between 12 and 22 °C (SUINAGA et al. 2013b). Winter lettuce crops usually have a vegetative cycle of 60 to 80 days, while in summer, the shorter cycle (50 to 70 days) may be a problem for farmers due to a reduction in leaf development and consequent volume loss of head lettuce (FILGUEIRA 2008, FUKUDA et al. 2012).

In environmental conditions of high temperatures, there is a stimulus to early bolting (LAFTA et al. 2021). High temperatures accelerate the lettuce plants' vegetative phase, inducing stem elongation,

emission of the floral tassel, reduction in leaf production, in addition to the production of latex with bitter taste (MOU 2008, LUZ et al. 2009, AL-SAID et al. 2018, HAO et al. 2021). Genotypes more susceptible to early bolting may manifest this characteristic in the seedling production phase (BLIND et al. 2017).

The interaction between temperature and light affects growth and nutrient absorption in lettuce plants (ZHOU et al. 2019, AIRES et al. 2020). Furthermore, high light intensity during lettuce cultivation also causes photoinhibition, reducing photosynthetic capacity and plant development (LONG et al. 1994, FU et al. 2012). This sensitivity of lettuce plants to high temperatures and high light intensity are a crucial environmental limiting factor for lettuce cultivation (FORMISANO et al. 2021). However, with the plants genetic breeding programs and constant availability of new cultivars, the farmer can choice genetic materials more adapted to local climatic conditions improving productivity and lettuce yield quality (LÉDO et al. 2000, LEE et al. 2015, AFTON et al. 2020).

Research has been carried out to identify the most suitable environments, as well as the lettuce cultivars more adapted to growth under high temperature and light conditions (SUINAGA et al. 2013a, SILVA et al. 2015, FLÔRES et al. 2016, ZUFFO et al. 2016, FERNANDES et al. 2019, LAFTA et al. 2021) making possible a better phenotypic expression of these cultivars. In Amazonas, lettuce production is concentrated in the city of Manaus and the metropolitan region (REIS & MADEIRA 2009). Studies indicate that the genotype x environment interaction can be decisive in producing lettuce in this region (BLIND et al. 2012). Therefore, it is important to evaluate the productive performance of lettuce cultivars in the southern Amazonas state because there is little research about cultivar competition in this region. Thus, the objective of this work was to evaluate the productive performance of nine lettuce cultivars in greenhouse in municipality of Humaitá (AM).

The experiment was carried out in urban areas in Humaitá, southern Amazonas state. In this region the climate is tropical rainy with a short dry season, according to Köppen's classification. As a result, the average temperature varies between 25,2 and 26,4 °C with average annual precipitation of 2193,6 mm, and air relative humidity 84,9% (INMET 2009). Figure 1 shows the temperature data in Humaitá, during the period of development of the experiment.

In the experimental area soil samples were collected from 0.0-0.2 m depth for physical and chemical analysis. The analyses were performed using Embrapa's methodology (EMBRAPA 2009). The results from the chemical attributes were pH 5.50 (in water); 42.0 g dm^{-3} of organic carbon; 16.3 mg dm^{-3} of P; 82.0 mg dm^{-3} of K; 5.18 $cmol_c$ dm^{-3} of Ca; 1.25 $cmol_c$ dm^{-3} Mg; 0.1 $cmol_c$ dm^{-3} Al; 5.38 $cmol_c$ dm^{-3} of H+Al and base saturation, 55.2%; 218 mg kg^{-1} of Fe; 19.1 mg kg^{-1} of Zn; 70.0 mg kg^{-1} of Mn; 2.10 mg kg^{-1} of Cu. Texture analysis showed 569 g kg^{-1} of sand; 159 g kg^{-1} of silt and 272 g kg^{-1} of clay.

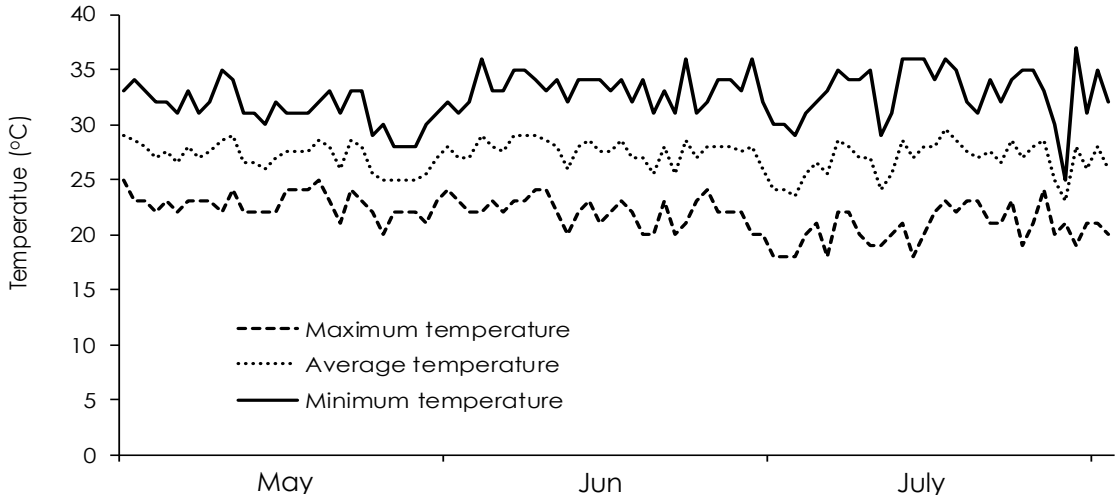

Figure 1. Meteorological data of minimum, average, and maximum temperature (ºC) in the period from May to July 2014 in Humaitá/AM.

The statistical design used was randomized complete blocks using nine cultivars (treatments) with four replications per treatment. The cultivars used were Rafaela and Hanson, Veneranda, Mônica SF 31, Simpson, Solaris, Elba, Quatro Estações and Babá de Verão. Sowing was carried out in 128-cell expanded polystyrene trays with Plantmax® substrate. Five seeds were sown in each cell and after seedling emergence, thinning was carried out, leaving one seedling per cell.

The seedlings with four to six leafs (24 days after sowing) were transplanted in beds prepared using a rotary tiller. The greenhouse was covered with a 100 micra polyethylene transparent agrofilm. It was used 100 mL of sheep manure and 11 g of 4N-14P-8K fertilization per plant, two days before planting the seedlings. Incorporation was performed manually. Two applications with 18 g of urea diluted in 2 L of water for each plot were carried out 20 and 27 days after transplanting.

The experimental area consisted of two beds with 33-m-long and 1-m-wide. It was used 30 cm between rows and 30 cm between plants in the row. Each plot consisted of six rows with three plants each, totaling 18 plants per plot. Weed control was carried out manually in the beds before and after planting the lettuce seedlings. All area was irrigated overhead with conventional sprinkler systems twice a day, morning and afternoon.

Five plants per plot were harvested 32 days after transplanting, manually. The parameters used in the evaluation of the productive performance of the plants were plant diameter (measuring the distance between the opposite edges of the plant); number of leaves (after cutting the plant close to the ground, each leaf was removed and counting); stem length (measuring the stem after removing the leaves); shoot dry mass (the leaves and stems of the plants were placed in a paper bag and dried in an oven with forced air circulation at 65 ºC until constant mass, then weighed by using an electronic semi-analytical balance).

In the statistical analysis, the data were submitted to the verification of the normality of the residues and the homogeneity of the variances. Then, the data were analyzed using ANOVA and the comparison of means, when significant (F-test, $p<0.05$), was performed using the Scott-Knott test at 5% probability, using the SISVAR statistical software (FERREIRA 2011).

The summary of the analysis of variance shows that there were no significant differences for plant diameter, despite the genetic diversity present in the experiment. In the other hand, there were differences between lettuce cultivar to shoot dry matter, stem length and number of leaves (Table 1).

Table 1. Analysis of variance of data on plant diameter (PD), shoot dry matter (SDM), stem length (SL) and number of leaves (NL) of lettuce cultivars grown in greenhouse in the municipality of Humaitá/AM.

SV	DF	Mean Squares			
		PD	SDM	SL	NL
Blocks	3	12.272869	3.451314	4.599296	19.381418
Cultivars	8	14.877231^{ns}	3.599462*	225.444907*	60.903884*
Residual	24	6.486934	1.494026	8.966492	8.951316
C.V. (%)	-	7.55	16.95	27.62	13.20

*Significant at 5% probability; SV: source of variation; DF: degrees of freedom; C.V.: coefficient of variation.

The cultivars Babá de Verão, Hanson, Simpson, Rafaela, Veneranda, and Elba significantly had the highest mean value of shoot dry matter (Table 2). Cultivar Elba also presented higher mean values of dry matter and number of leaves when cultivated in Bananeiras, Paraíba state (SANTOS et al. 2011). The availability of cultivars and knowledge of plant development in different cultivation environments, as observed by RESENDE et al. (2017), enables the selection of genetic materials with greater productive capacities and heat tolerance, in addition to the possibility of increasing the lettuce cultivated areas and growing seasons (LAFTA et al. 2017).

DAMASCENO et al. (2011), studying the performance of lettuce cultivars grown in pots in the municipality of Tabatinga, Amazonas state, found 10.06 g of shoot dry matter for cultivar Babá de Verão and 6.44 g for cultivar Rafaela. Also, SANTOS et al. (2011), working with the commercial production of lettuce cultivars in Bananeiras, verified that the Elba cultivar had the highest mean value of dry leaf mass (7.96 g per plant). These results corroborate the data observed in the present work and indicate the good productive capacity of these cultivars, even under higher temperatures conditions.

The cultivars Simpson and Quatro Estações had the stem length significantly greater, 29.86 and 13.72 cm, respectively. This characteristic of early stem elongation of these cultivars indicates low resistance to the induction of bolting due to high temperatures and high luminosity intensity. Early bolting induction difficult the cultivation of these genetic materials, demanding early harvest to these cultivars in the region. In Manaus, even the best-adapted cultivars must be harvested before 48 to 50 days after sowing due to the high temperatures in the region (RADIN et al. 2004).

Also, FERNANDES et al. (2019) observed that the cultivar Simpson had greater stem elongation as well as the presence of latex, reducing harvested lettuce quality. LÉDO et al. (2000) working with lettuce in

the State of Acre verified 23.1 cm of stem length to cultivar Simpson, being the cultivar with the longest stem length compared to the other evaluated cultivars.

Table 2. Mean and standard error of plant diameter (PD), shoot dry matter (SDM), stem length (SL) and number of leaves (NL) of lettuce cultivars grown in greenhouse in the municipality of Humaitá/AM.

Cultivars	PD (cm)	SDM (g)	SL (cm)	NL (nº)
Simpson	31.00 ± 1.11 a	7.95 ± 0.37 a	29.86 ± 3.10 c	24.07 ± 1.23 a
Quatro Estações	31.22 ± 1.84 a	5.75 ± 0.69 b	13.72 ± 2.01 b	25.04 ± 1.04 a
Babá de Verão	32.47 ± 0.79 a	8.40 ± 0.54 a	6.82 ± 0.54 a	29.43 ± 0.73 a
Rafaela	33.36 ± 0.88 a	7.64 ± 0.62 a	6.89 ± 0.93 a	19.54 ± 0.79 b
Solaris	33.86 ± 1.08 a	6.07 ± 0.82 b	6.04 ± 0.31 a	18.71 ± 1.45 b
Mônica SF 31	34.79 ± 2.23 a	6.26 ± 0.57 b	8.43 ± 1.37 a	19.11 ± 1.24 b
Hanson	34.82 ± 0.56 a	8.02 ± 0.46 a	10.04 ± 1.23 a	19.82 ± 0.89 b
Veneranda	35.64 ± 0.24 a	7.42 ± 0.72 a	7.46 ± 0.44 a	21.18 ± 0.56 b
Elba	36.61 ± 2.01 a	7.39 ± 0.92 a	7.97 ± 0.76 a	27.14 ± 3.78 a
C.V. (%)	7.55	16.95	27.62	13.20

Means followed by the same letter in the columns are not statistically different by Scott-Knott test at 5% probability. C.V.: coefficient of variation.

High temperatures during the lettuce cultivation can also affect the turgor of the leaves and contribute to leaves showing necrosis called “tipburn” due to the deficit of calcium in the edges of the leaves (MACIAS-GONZÁLEZ et al. 2019). Thus, genetic improvement works have been carried out to select resistant genotypes (SUINAGA et al. 2013b).

To number of leaves (NF), the highest means were observed to cultivars Babá de Verão, Elba, Quatro Estações and Simpson, with 29.43; 27.14; 25.04 and 24.07 leaves respectively, while cultivars Rafaela, Solaris, Mônica SF 31, Hanson and Veneranda showed the lowest leaf number. SANTOS et al. (2009) also observed that cultivar Elba was promising for cultivation under high temperatures and light conditions in the municipality of Cáceres. This work found that cultivar Elba present the highest mean value of leaves per plant (19.4) and the cultivar Veneranda had the worst performance for number of leaves, with an average of 11.4. CARVALHO et al. (2020) also observed a better performance of the cultivar Elba at high temperatures in Juazeiro, Bahia.

The number of leaves per plant is a genetically determined characteristic, but under conditions of high temperatures and light, the early bolting induction makes early harvesting necessary and, therefore, there is a smaller number of leaves in the lettuce for commercialization. Both the number of leaves and plant weight are important characteristics in lettuce production and can be affected by photoperiod and temperature conditions during cultivation (OLIVEIRA et al. 2004).

SILVA et al. (2015) observed that there was no variation in the productivity of the cultivar Babá de Verão in two growing seasons, indicating a greater resistance of this cultivar to climatic variations. Other studies have been carried out in the state of Amazonas to identify cultivars better adapted to growing conditions in different regions (DAMASCENO et al. 2011, BLIND et al. 2012, BLIND & SILVA FILHO 2015).

Thus, it was verified through the characteristics of diameter, dry mass, stem size and number of leaves that the cultivars Babá de Verão and Elba were promising for cultivation in the region of Humaitá.

Cultivars Babá de Verão and Elba presented better agronomic performance for cultivation in greenhouse in municipality of Humaitá, Amazonas state.

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