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Morphological and productive aspects of lettuce in low altitude and latitude[1]

Aspectos morfológicos e produtivos de cultivares de alface em baixa altitude e latitude

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ABSTRACT - Lettuce is considered a crop of mild climate and its production in regions of low altitude and latitude is impaired due to the high temperatures and the predominance of long days. Therefore, the aim of this study was to evaluate the behavior of lettuce cultivars in such conditions. An experiment was conducted at the *Horta Didática* of the Federal University of Ceará, Campus do Pici, in Fortaleza. Nine lettuce cultivars from three commercial groups were used and distributed in a randomized block design, with four replications. The following qualitative traits were evaluated: bolting, head formation, leaf texture, anthocyanin and phytosanitary status for pest and disease infestation. Regarding the quantitative traits, plant height, plant diameter, fresh marketable weight (FMW), and non-marketable (FNMW) total fresh weight (TFW), dry marketable weight (DMW) and non-marketable (DNMW), total dry weight, chlorophyll *a*, chlorophyll *b*, chlorophyll *a/b* ratio. Data were submitted to analysis of variance and, later, grouping test was performed. None of the cultivars presented head formation but all presented early bolting. The cultivars showed no difference for FMW, however, Babá de Verão produced almost 72% more than Repolhuda Brasil from the same group. Regarding FMW, the most productive cultivars were Babá de Verão, Crespa para Verão, Americana Delícia, Crespa Repolhuda and Kaiser. However, Babá do Verão and Crespa stood out for DMW.

Key words: *Lactuca sativa* L.. Bolting. Yield. Commercial groups.

RESUMO - A alface é considerada uma cultura de clima ameno e sua produção em regiões de baixa altitude e latitude é prejudicada principalmente devido às elevadas temperaturas e à predominância de dias longos. Assim, objetivou-se avaliar o comportamento de cultivares de alface numa condição que apresentasse essas características. Para isto, conduziu-se um ensaio na Horta Didática da Universidade Federal do Ceará, *Campus* do Pici, em Fortaleza. Utilizaram-se nove cultivares de alface de três grupos comerciais, distribuídos no delineamento em blocos casualizados, com quatro repetições. Foram avaliadas as características qualitativas, idade de pendoamento, formação de cabeça, textura da folha, antocianina e, estado fitossanitários das plantas quanto a infestação por pragas e doenças. Em relação às características quantitativas avaliaram-se, altura das plantas, diâmetro das plantas, massa fresca comercializável (MFC) e não comercializável (MFNC), massa fresca total (MFT), massa seca comercializável (MSC) e não comercializável (MSNC), massa seca total (MST), clorofila *a*, clorofila *b* e, relação clorofila *ab*. Os dados foram submetidos a análises de variância e, posteriormente, realizado o teste de agrupamento. Nenhum dos cultivares apresentou formação de cabeça, mas todos pendoaram precocemente. Os cultivares não apresentaram diferença para MFC, porém, Babá de Verão produziu quase 72% a mais que Repolhuda Brasil, de seu mesmo grupo. Quanto à MFT, os cultivares mais produtivos foram Babá de Verão, Crespa para Verão, Americana Delícia, Crespa Repolhuda e Kaiser. Contudo, para MSC apenas Babá de Verão e Crespa se sobressaíram. Esses últimos, juntamente com Crespa Repolhuda, foram os que apresentaram também os maiores valores de MST.

Palavras-chave: *Lactuca sativa* L.. Pendoamento. Produtividade. Grupos Comerciais.

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INTRODUCTION

Lettuce (*Lactuca sativa* L.) is the most popular leafy vegetable and, therefore, presents the greatest economic importance within this group. It also stands out from the social point of view since it is traditionally cultivated by small Brazilian producers. However, its relevance is not only national once it is present in the diet of a large part of the world's population (HEREDIA ZARATE *et al*., 2010; SALA; COSTA, 2012).

It is considered a plant of subtropical climate because it produces quality leaves at temperatures between 12 and 22 °C. However, when submitted to temperatures above 22 °C, it is stimulated to emit plant bolting more quickly, culminating in the stoppage of its vegetative phase (RODRIGUES *et al*., 2008). When it happens, the product is unfit for consumption, due to the bitter taste from latex accumulation (VARGAS; DUARTE; ZECCHINI, 2014).

The length of the day also interferes with the cycle of this species. Days with more than 10 hours of light greatly influence their development. In general, this condition promotes early bolting (FILGUEIRA, 2008; SANTOS *et al*., 2009). Therefore, temperature and day length are crucial in the production of lettuce in regions of low altitude and latitude, such as the Brazilian Northeast. Then, marketers and traders routinely acquire lettuce from regions or municipalities that present more favorable climatic conditions for its cultivation.

Despite the difficulties mentioned above, professionals from phytotechnology and plant breeders have been working on the development of techniques and the improvement of this species to enable quality productions throughout the year. However, even with all the efforts made to increase the productive and visual efficiency of lettuce, little has been done in low altitude and latitude regions, which are typical of the North and Northeast regions of Brazil. These areas are dependent on the cultivation of lettuces developed for environments that present completely different climatic conditions, causing, in most cases, a marked reduction in yield and quality.

According to Disqual (2001), farmers should be attentive to the choice of the most appropriate cultivar, as well as the quality of the propagating material. An incorrect choice can result in damages to producers, even with the correct management. Thus, this study aimed to describe morphological and productive aspects of lettuce cultivars under low altitude and latitude climatic conditions.

MATERIAL AND METHODS

The experiment was conducted in a field belonging to *Horta Didática*, in the Plant Science Department of the Federal University of Ceará, Campus Pici, in Fortaleza-Ceará (3º44´ S e 38º33´ W and altitude of 21 m). According to Köppen, the climate of the region is classified as type Aw '(tropical with dry season).

The experiment was conducted from March to April 2014. During the cycle, the temperature ranged from 23 to 30.6 °C, 70-80% relative humidity, insolation from 10.6 to 11.6 $h.day^{-1}$ and precipitation from 50 to 272 mm. Data were obtained at the meteorological station of the Department of Agricultural Engineering, 2 km away from the work location.

Nine lettuce cultivars were used: two of the group Lisa Repolhuda (Babá de Verão Manteiga and Repolhuda Brasil 303), three of the group Crespa Solta (Crespa Para Verão, Marianne and Elba) and four of Crespa Repolhuda (Americana, Americana Delícia, Crespa Repolhuda and Kaiser). These cultivars were distributed in the experimental field by a randomized blocks design, with four replications. The plot consisted of sixteen plants, but nine plants were considered as useful area, as recommended by Lúcio *et al*. (2011).

The production started from the sowing of each of the evaluated cultivars in polypropylene trays of 162 cells previously filled with a substrate formulated with an organic compost, coconut fiber and chicken litter (3:1:1v.v.). These trays were left until the emergence of plants in an environment with 71 ± 5% humidity and 23 ± 2 °C air temperature. After this period, they were transferred to a protected environment covered with screen mash 30%. The thinning was carried out at 14 days after sowing (DAS). Five kilos of organic compound per square meter was incorporated in each block (Table 1). This compound was produced by the deposition of organic material, such as leaves, twigs, vegetable residues interspersed with bovine manure.

One week after the incorporation, five simple samplings were performed in each block. For each one, a composite sample of soil was made, later sent for fertility analysis in the Soil Laboratory of the Soil Science Department of the Federal University of Ceará (Table 1).

The seedlings transplanting was performed at 23 DAS (when the seedlings presented from 4 to 6 definitive leaves), distributed in spacing of 0.20 m x 0.20 m. Weeding, pest and disease control were carried out whenever necessary, according to the crops need. Micro-sprinkler was used for irrigation twice a day (early morning and late afternoon). Regarding the fertilization, two coverage applications were performed at 33 and 43 DAS, with 3 kg of the organic compound per m^2.

The evaluation started at 53 DAS when there was a change from the vegetative phase to the reproductive

Table 1 - Chemical analysis of the soil and the organic compound used to produce seedlings and of the blocks used in the study, one week after the incorporation of the compound

Parameters	O.C	B1	B2	B3	B4
N (g kg^{-1})	4,40	2,20	3,00	2,90	2,20
P (mg dm^{-3})	983	1246	1061	783	656
K^+ (mg dm^{-3})	1400	301	426	470	329
Na^+ (mg dm^{-3})	22,00	64,00	95	168	85
Ca^{2+} ($cmol_c$ dm^{-3})	11,20	10,50	8,40	8,20	6,20
Mg^{2+} ($cmol_c$ dm^{-3})	10,80	8,00	6,20	3,30	5,00
Al^{3+} ($cmol_c$ dm^{-3})	0,00	0,10	0,00	0,00	0,05
pH in H_2O	7,40	7,10	7,00	7,10	7,40
CEC ($cmol_c$ dm^{-3})	23,42	18,87	15,12	12,14	11,61
EC (dS m^{-1})	1,00	0,93	0,69	0,78	1,03

O.C - Organic compound; B1, B2, B3, B4 - Blocks; N - Nitrogen; P - Phospor; K^+- Potassium; Na^+- Sodium; Ca^{2+}- Calcium; Mg^{2+}- Magnesium; Al^{3+}- Aluminum; pH - Potential of hydrogen; CEC - cation exchange capacity; EC - Electrical conductivity

was identified, indicated by the plant bolting. Regarding the qualitative evaluations, it was observed: age of bolting - defined by DAS by daily observation of the stem elongation; head formation (present or absent); leaf texture (crisp or smooth); anthocyanin (present or absent); phytosanitary status of plants for pest infestation; and, phytosanitary status of plants for disease infestation. The last two characteristics were evaluated based on a visual scale of grades proposed by Mota *et al*. (2003), with a variation from 1 to 5 (1- plants with highly lesioned leaves, 2- abundant presence of lesions in external leaves, 3- plants with moderately injured leaves, 4 plants with rarely injured leaves, and 5- plants without lesions in leaves).

For the quantitative evaluations, it was observed: plant height (PH) - determined from the measurement of the insertion point of the plant in the soil to the shoot apical bud; plants (PD) - determined from the distance between the edges of different and opposite leaves; chlorophyll *a* and *b* (CLOR a and CLOR b) - before harvesting, the indirect measurement of non-destructive measurements was performed with Chlorophyllometer SPAD-502 (*Minolta Camera Co. Ltd., Japan*). The youngest leaf which was totally developed was used for this measurement. This evaluation was carried out at harvest. Then, chlorophyll a / b ratio was determined.

The plants were then harvested around 6 and 7 in the morning, and the shoot part was separated in marketable (leaves without lesions or apparent damage) and non-marketable (leaves with lesion or apparent damage) and then weighed on a digital scale with accuracy of 4 decimal places to determine fresh marketable weight (FMW), non-marketable (FNMW) and total (TFW). After the determination of the fresh weight, the plants were placed in paper bags and then dried in a forced air circulation oven with temperature ranging from 65 to 70 °C for 48 hours to determine dry marketable weight (DMW), non-marketable (DNMW) and total (TDW). The results of all weights were expressed in g.

Data were submitted to analysis of variance through the hierarchical model:

$$y_{ijk} = m + t_i + g_j + t/g_{ij} + b_k + e_{ijk}$$

where y_{ijk} is the effect of observing the *i-th* cultivar of the *j-th* commercial group in the *k-th* block; *m* is the overall mean of the experiment; t_i is the effect of the *i-th* cultivar; g_j is the effect of the *j-th* commercial group; t/g_{ij} is the effect of the *i-th* cultivar within the *j-th* commercial group; b_k is the effect of the *k-th* block and; e_{ijk} the effect of the error associated with the *i-th* cultivar of the *j-th* commercial group in the *k-th* block. The treatments were ramdomly distributed in the plots within each block.

Subsequently, the grouping test was performed using the Scott-Knott procedure at 0.05 probability. At first, a comparison was made involving all the cultivars, regardless the commercial group. Later, the test was applied between cultivars within each commercial group. All the statistical analyzes were performed with the computational application in Genetics and Statistics GENES (CRUZ, 2013).

RESULTS AND DISCUSSION

In general, the analysis of the qualitative characteristics (Table 2) showed the highest production precocity for the cultivars of groups I and II (Lisa

Table 2 - Visual morphological evaluation of nine lettuce cultivars of three commercial groups (Group I - Lisa Repolhuda; Group II - Crespa Solta; Group III - Crespa Repolhuda)

Cultivar	Beginning of bolting	Head formation	Type of lettuce1	Anthocyanin	Disease	Pest
Babá de Verão Manteiga(I)	52	Absent	Loose Smooth	Absent	5	5
Repolhuda Brasil 303(I)	52	Absent	Loose Smooth	Absent	5	5
Crespa para Verão(II)	52	Absent	Loose Crisp	Absent	5	5
Marianne(II)	52	Absent	Loose Crisp	Absent	4	5
Elba(II)	52	Absent	Loose Crisp	Absent	5	5
Americana(III)	53	Absent	Loose Crisp	Absent	4	4
Americana Delícia(III)	54	Absent	Loose Crisp	Absent	5	3
Crespa Repolhuda(III)	52	Absent	Loose Crisp	Absent	5	4
Kaiser(III)	54	Absent	Loose Crisp	Absent	5	4

(I), (II) e (III) cultivars belonging to commercial groups I, II and III respectively; [1]Types of lettuce: Loose Crisp: presents more consistent, crisp and loose leaves, without head formation. Depending on the cultivar, the leaves may have green or purple coloring. Purple is characteristic of anthocyanin accumulation. Loose Smooth: presents loose and smooth leaves with no head formation; [2]Evaluation of phytosanitary status of plants based on a visual scale of grades, from 1 to 5 (1 plants with external leaves heavily attacked by leaf diseases / pests, 2) abundant presence of lesions on outer leaves, 3) moderate presence of lesions on outer leaves, 4 - scarce lesions on the outer leaves, and 5- plants with highly healthy leaves)

Repolhuda and Crespa Solta, respectively), which at 52 days after sowing (DAS) started the bolting process. The cultivars of Crespa Repolhuda (Americana Delícia and Kaiser) resisted two more days before bolting.

The combination of long days (10.6 to 11.6 h light) with high temperatures (averages of approximately 27 °C) influenced the early bolting of all cultivars in this study (FILGUEIRA, 2008; SANTOS *et al*., 2009). Diamante *et al*. (2013) working with cvs. Regina, Elizabeth, Elisa and Regiane, observed mean values of bolting of 82; 80; 79 and 81 DAS, respectively, in Cáceres-MT.

Head formation was not observed in any of the cultivars. This result shows relevant importance, because six out of the nine cultivars are commercialized as lettuces that form head (Babá de Verão Manteiga, Repolhuda Brasil 303, Americana, Americana Delícia, Crespa Repolhuda and Kaiser). A possible explanation for this morphological alteration may be related to temperature. For lettuce crops, air temperature is the main conditioning element of its development, interfering both in the emission of leaves and in the change of phenological stages (HERMES *et al*., 2001). According to Bezerra Neto *et al*. (2005), due to the Mediterranean origin of lettuce, part of its genetic load responds differently when submitted to different temperature conditions. Temperatures above 27 ^{o}C are considered high and promote an accelerated development of the plant, with elevation in the distance between the leaves internodes, with early bolting without head formation. According to Fabri (2007), for head formation in lettuce, the internodes need to be short, and it only happens when the plants are cultivated at milder temperatures.

The type or group in which each cultivar was commercially framed was different for Babá de Verão Manteiga, Repolhuda Brasil 303, Americana, Americana Delícia, Crespa Repolhuda and Kaiser. Although commercially disclosed as group Repolhuda Lisa, in the present work, the two first cultivars presented typical characteristics of the group Solta Lisa. The last four, commonly cited as belonging to the group Repolhuda Crespa were morphologically classified as belonging to the group Solta Crespa (KRISTKOVA *et al*., 2008). The differences observed in the classification groups of lettuces are mainly related to the greater spacing observed between the leaves produced in the cultivars, which makes it impossible to form the head.

Regarding anthocyanin, none of the cultivars presented any apparent trace of this pigment. This was already expected, since all the cultivars presented only the green color in the description of the seeds commercial packages.

Regarding the phytosanitary status of plants for the disease factor, except for cvs. Marianne and Americana, which presented scarce lesions on older leaves, typical of the disease known as Cercospore Spot, the others did not show spots and were considered healthy. However, regarding the phytosanitary status for the pest factor, cvs. Babá de Verão, Repolhuda Brasil 303, Crespa para Verão, Marianne and Elba showed high sanity, as they did not present predation injuries. On the other hand, all those cvs. belonging to the commercial group Crespa Repolhuda suffered some type of predation, for example cv. Americana Delícia which presented the lowest grade (3). For Sala and Costa (2012), crisp lettuces tend to be more resistant to diseases and pest attacks than those

classified as smooth. However, this was not observed in the present study.

The effect of cultivar was significant for almost all the evaluated traits, except the FMW (Tables 3 and 4). For group, no effect was observed for FMW, TFW, DMW, DNMW and TDW. For the cultivars within the groups, there were differences for all characteristics except for the chlorophyll a/b ratio and the FMW and FNMW. Regarding the effect of cultivars within group I (C/GI), differences were observed for the characteristics PD, FMW and TFW, DMW and TDW. On the other hand, for the cultivars within the GII presented differences only for PD, whereas for those belonging to GIII there was difference in relation to PH, PD, chlorophyll a and chlorophyll b, FNMW, DNMW and TDW.

It was observed that GIII cultivars were the ones with the lowest plant height, except *Crespa Repolhuda* (Table 5). GIII cultivars present, on average, 4.15 cm of height at harvesting, not showing differences among themselves. Analyzing this result with the qualitative aspect of bolting (Table 2), a certain tolerance of these cultivars is observed in the present climatic conditions. These results corroborate with Santos *et al*. (2009), who related lower values of height with late bolting in lettuce cultivars.

Table 3 - Summary of analysis of variance for plant height (PH, cm), plant diameter (PD, cm), chlorophyll *a* (CLOR a), chlorophyll *b* (CLOR b) and chlorophyll *a* and *b* ratio (CLOR ab) in nine lettuce cultivars in three commercial groups (Group I - Lisa Repolhuda; Group II - Crespa Solta; Group III - Crespa Repolhuda)

SV	DF	Mean squares				
		PH	PD	CLORa	CLORb	CLOR ab
Cultivar (C)	(8)	10.54**	26.05**	42.87**	2.12**	0.73**
Group (G)	2	10.06**	26.26**	142.03**	6.69**	2.28**
C/G	6	10.69**	25.98**	9.82**	0.60**	0.21^{ns}
C/GI	1	1.04^{ns}	21.26*	0.06^{ns}	0.05^{ns}	0.27^{ns}
C/GII	2	1.40^{ns}	33.32**	0.29^{ns}	0.01^{ns}	0.02^{ns}
C/GIII	3	20.12**	22.66**	19.44**	1.17**	0.32^{ns}
Resíduo	24	0.94	3.44	1.83	0.02	0.13
Mean		6.06	30.06	17.15	2.79	6.26
CVe (%)		15.97	6.17	7.89	5.33	5.68

^{ns} not significant, ** and * significant at 1 and at 5% probability, respectively, by the F test

Table 4 - Summary of analysis of variance for fresh marketable weight (FMW, in g) and non-marketable (FNMW in g), total fresh weight (TFW in g), dry marketable weight (DMW in g) and non-marketable (DNMW in g), total dry weight (TDW, in g) in nine lettuce cultivars of three commercial groups (Group I - Lisa Repolhuda; Group II - Crespa Solta; Group III - Crespa Repolhuda)

SV	DF	Mean Squares					
		FMW	FNMW	TFW	DMW	DNMW	TDW
Cultivar (C)	(8)	317.03^{ns}	135.07*	396.27*	0.96**	0.98*	1.74*
Group (G)	2	61.44^{ns}	232.54*	84.33^{ns}	0.40^{ns}	0.98^{ns}	0.17^{ns}
C/G	6	402.23^{ns}	102.58^{ns}	500.24**	1.15**	0.99*	2.27**
C/GI	1	2145.13**	2.00^{ns}	2016.13**	5.75**	0.03^{ns}	4.99**
C/GII	2	80.77^{ns}	46.94^{ns}	250.77^{ns}	0.29^{ns}	0.12^{ns}	0.77^{ns}
C/GIII	3	35.57^{ns}	173.19*	161.26^{ns}	0.19^{ns}	1.88**	2.36*
Residue	24	202.68	44.07	137.29	0.22	0.40	0.61
Mean		62.23	15.21	77.44	3.27	1.06	4.33
CVe (%)		22.88	43.65	15.13	14.49	59.38	18.05

^{ns} not significant, ** and* significant at 1 and 5% probability, respectively by the F test

Table 5 - Means of plant height (PH, cm), plant diameter (PD, cm), chlorophyll *a* (CLOR a), chlorophyll *b* (CLOR b) and chlorophyll a and b ratio (CLOR ab) in nine lettuce cultivars of three commercial groups (Group I - Lisa Repolhuda; Group II - Crespa Solta; Group III - Crespa Repolhuda) cultivated under low altitude and latitude

Cultivars	PH	Traits			
		PD	CLOR a	CLOR b	CLOR ab
Babá de Verão Manteiga (I)	7.28 aB	30.35 aB	16.88 aC	2.63 aD	6.44 aA
Repolhuda Brasil 303 (I)	6.56 aB	27.09 bB	16.71 aC	2.47 aD	6.80 aA
Crespa para Verão (II)	6.78 aB	34.41 aA	13.40 aD	2.07 aE	6.49 aA
Marianne (II)	7.05 aB	28.67 bB	13.90 aD	2.13 aE	6.53 aA
Elba (II)	5.92 aB	32.07 aA	13.47 aD	2.04 aE	6.64 aA
Americana (III)	4.63 bC	32.90 Aa	22.82 aA	4.18 aA	5.49 aB
Americana Delícia (III)	4.50 bC	27.35 bB	20.53 bB	3.44 bB	5.99 aB
Crespa Repolhuda (III)	8.48 aA	28.72 bB	17.67 cC	2.89 cC	6.15 aB
Kaiser (III)	3.33 cC	29.02 bB	19.03 bB	3.27 bB	5.84 aB

(I), (II) e (III) cultivars of the comercial groups I, II and III, respectively; Means followed by the same capital letter in the column did not differ statistically by the Scott-Knott test ($p < 0.05$) and showed global differences among all cultivars; Means followed by the same lowercase letter in the column did not differ statistically by the Scott-Knott test ($p < 0.05$) and showed global differences between cultivars of the same commercial group

For PD, the cultivars Crespa para Verão and Elba from GII and the cultivar Americana from GIII presented mean diameter of the superior shoot part of 32 cm. Within the GI, the cultivar Babá de Verão Manteiga was superior, presenting average diameter of 30.35 cm. Plant diameter is an important characteristic from the standpoint of lettuce marketing, because plants with larger diameter tend to draw more attention from consumers at purchasing (REGHIN *et al*., 2002).

Rodrigues *et al*. (2008), working with crisp cultivars in the climatic conditions of Manaus-AM, similar in temperature and humidity to the city of Fortaleza (27 °C and 60%), observed plant diameter varying from 13.60 to 27.73 cm at 58 DAS, which are lower values than those obtained in this work at 53 DAS.

The difference in diameter observed between the two studies can be related to two factors: the first is the genetic difference among the cultivars, which can present totally different morphological and productive characteristics even under similar climatic conditions; the second one, which would explain the observed difference, would be related to the way of implantation and conduction of the crop (spacing, fertilization, duration of the major cycle, etc.), which can substantially interfere in the development of plants of any cultivar.

Cultivar Americana stood out for chlorophyll *a* and *b*, cv. (22.82 and 4.18, on average) among the nine cultivars. For chlorophyll *ab* ratio, the cultivars of the commercial groups Lisa Repolhuda and Crespa Solta stood out in relation to the group Crespa Repolhuda, with means of 6.58 and 5.86, respectively.

The thylakoid membranes of all plants contain these two different forms of chlorophyll (a and b). The chlorophyll *a* is found in all reaction centers and antennas, in which chlorophyll *b* is also found (BUCHANAN; GRUISSEM; JONES, 2000). Both are related to the accomplishment of the photosynthetic process in plants (TAIZ; ZEIGER, 2013). Chlorophyll *a* is used to perform the photochemical phase of photosynthesis, since chlorophyll *b* acts more as an accessory pigment, aiding in the absorption of light and energy transfer to the reaction centers (STREIT *et al*., 2005). Despite cv. Americana presented the highest value of chlorophyll, it was not the one that presented the greatest mass production. This can happen, because under high temperatures and light, photoinhibitory damage can occur and cause reduction in pigments (TAIZ; ZEIGER, 2013).

By the values of the chlorophyll *ab* (CLORab) relation, it was observed that the insolation of the environment in this work was quite high. This is because the ratio is usually 3: 1 and, in the present work, the cultivars presented values ranging from 5.49: 1 to 6.80: 1. However, they did not show differences among them. These values are within the ones observed by Boardman (1990), who concluded that the lower the value of this ratio, the lower the luminous intensity due to an increase of chlorophyll *b* in shaded environments.

Obviously, not only the content of chlorophyll *a* and *b* will influence on the photosynthesis, but also the interaction of several factors with the genetic load of the plant. Thus, together, they can produce less or more productive plants.

Regarding FMW, no difference was observed among the evaluated cultivars, which presented, on average, a production of 62.23 g plant^{-1} (Table 6). Among the different commercial groups in the present study, there was difference only in GI, with emphasis for Babá de Verão that produced plants with fresh marketable weight of 78.38 g, almost 72% more mass than Repolhuda Brasil 303. Santi *et al*. (2010), also worked with Babá de Verão and obtained a fresh marketable weight value higher than that observed in this study (127.04 g). Probably, this difference occurred due to the higher doses of organic fertilization used by the authors and the climatic condition of the place, which presents an annual average temperature around 24 °C, which is considered ideal for the crop.

Probably, this difference occurred due to the higher doses of organic fertilization used by the authors and the climatic condition, which presents an annual average temperature around 24 °C, considered ideal for the crop.

GIII stood out negatively for FNMW. Three out of four cultivars of this group (Americana Delícia, Crespa Repolhuda and Kaiser) presented the highest fresh non-marketable weight (22.40 g on average). In a joint analysis of this characteristic with the phytosanitary status of the pest factor, it is possible to establish a partial relationship among the factors, since these three cultivars were also some of the ones that presented higher incidence of leaves predated by pests.

Regarding the TFW, five cultivars were considered the most productive (Babá de Verão, Crespa para Verão, Americana Delícia, Crespa Repolhuda and Kaiser) with a mean of 84.64 g, about 24% more than the other cultivars. For the commercial group Lisa Repolhuda, the cv. Babá de Verão was the most productive. However, for the other groups no difference was observed among the cultivars. Rodrigues *et al*. (2008) worked with different cultivars of crisp lettuce in the municipality of Iranduba-AM and observed mean values of total production (26.96 to 104.61 g plant^{-1}) and marketable (25.54 to 96.7 g plant^{-1}) similar to those obtained in this work. This is probably due to the similarity of the climatic conditions between that environment and Fortaleza-CE, as well as to the cultivars belonging to the same commercial group.

Santos *et al*. (2009), evaluating different cultivars of crisp lettuce, such as Elba and Marianne in Cáceres-MT, observed means of total production ranging from 52.5 to 111.5 g plant^{-1} and marketable production of 29.0 to 104.3 g plant^{-1}. In this aspect, cvs. Babá de Verão and Crespa para Verão, developed to be produced at higher temperatures, stood out (ISLA SEMENTES, 2014; TOP SEED GARDEN, 2014). However, they can be perfectly used in locations with high daily thermal averages throughout the year. This position is supported by Henz and Suinaga (2009), who point out the so-called "cultivars for summer" as the best adapted for production in the North and Northeast regions (higher temperatures and days with more constant photoperiod and over 10 hours of light).

For DMW, cvs. Babá de Verão (group Lisa Repolhuda) and Crespa para Verão (group Crespa Solta)

Table 6 - Means of fresh marketable weight (FMW, in g) and non-marketable (FNMW, in g), total fresh weight (TFW, in g), dry marketable weight (DMW, in g), non-marketable (DNMW, in g), and total dry weight (TDW in g) in nine lettuce cultivars of three commercial groups (Group I - Lisa Repolhuda; Group II - Crespa Solta; Group III - Crespa Repolhuda) cultivated under low altitude and latitude conditions

Cultivar	Traits					
	FMW	FNMW	TFW	DMW	DNMW	TDW
Babá de Verão Manteiga (I)	78.38 aA	11.88 aB	90.25 aA	4.28 aA	0.86 aB	5.14 aA
Repolhuda Brasil 303 (I)	45.63 bA	12.88 aB	58.50 bB	2.59 bB	0.97 aB	3.56 bB
Crespa para Verão (II)	69.75 aA	15.63 aB	85.38 aA	3.68 aA	1.02 aB	4.73 aA
Marianne (II)	63.25 aA	10.50 aB	73.75 aB	3.16 aB	0.74 aB	3.90 aB
Elba (II)	61.13 aA	9.13 aB	70.25 aB	3.30 aB	0.70 aB	3.99 aB
Americana (III)	61.56 aA	9.69 bB	71.25 aB	3.31 aB	0.72 bB	4.03 bB
Americana Delícia (III)	58.88 aA	24.81 aA	83.69 aA	2.92 aB	1.11 bB	4.02 bB
Crespa Repolhuda (III)	64.13 aA	21.25 aA	85.38 aA	3.27 aB	2.31 aA	5.58 aA
Kaiser (III)	57.38 aA	21.13 aA	78.50 aA	2.92 aB	1.16 bB	4.08 bB

(I), (II) e (III) cultivars belonging to commercial groups I, II and III respectively; Means followed by the same capital letter in the column did not differ statistically by the Scott-Knott test ($p<0.05$) and showed global differences among all cultivars; Means followed by the same lowercase letter in the column did not differ statistically by the Scott-Knott test ($p<0.05$) and showed global differences among cultivars of the same commercial group

were the most productive among all the evaluated cultivars. Babá de Verão also stood out within its commercial group. These cultivars presented, on average, 4.28 and 3.68 g plant^{-1}, respectively. Santos *et al*. (2009), worked with cvs. Itapuã, Elba and Veneranda, in Cáceres-MT, and observed higher values of dry weight than those obtained in this study (47.16 to 99.5 g plant^{-1}). The difference observed between the two studies may be related to the genetic difference between the cultivars, the way of implantation and conduction of the crop (spacing, fertilization, among others), as well as the season. All of them may interfere together or individually, but substantially in the development of the evaluated cultivars.

According to Tibbits and Bottemberg (1976), very low values of dry weight evidenced a higher speed of leaf expansion, probably due to high levels of air relative humidity. This may have happened in this work, because of the high temperatures, days with more than 10 h of light and mainly due to the micro sprinkler irrigation system. In spite of favoring the development of the visual appearance of the product, this accelerated growth hinders the accumulation of photoassimilates, which are used in the synthesis of structures that would be accounted as dry weight. This reduces their resistance to transportation and makes them more susceptible to damage during post-harvest handling. Regarding non-marketable dry weight, there was a negative highlight only for cv. Crespa Repolhuda (group Crespa Repolhuda), which produced on average 2.31 g plant^{-1}.

Among the nive cultivars, three could be highlighted for TDW (Babá de Verão Manteiga, Crespa para Verão and Crespa Repolhuda), presenting on average 5.15 g plant^{-1}. The cultivars Babá de Verão Manteiga and Crespa Repolhuda also stood out, since they differed from the others of their respective commercial groups. It was expected that the cv. Americana would be able to capture more light, directing this greater energy for the accomplishment of photosynthesis and, consequently, for the accumulation of photoassimilates, since it presented the highest values of chlorophyll a and b in the tissues. However, observing the MDW produced by this cultivar, it was verified that the higher levels of chlorophyll a and b produced were not able to be converted into higher yield, at least under the edaphoclimatic conditions of this work. Thus, studies involving correlations between these traits should elucidate their importance for yield.

CONCLUSION

The cultivars Babá de Verão Manteiga and Crespa para Verão presented the best visual and productive characteristics under the conditions of low altitude and latitude.

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