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Physiological potential of lettuce seeds crespa

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The present work aimed to evaluate the germination, emergence, vigor and initial development of lettuce (*Lactuca sativa* L.) cultivars. Nine cultivars belonging to the crespa group, Cinderella, Monica SF 31, Mimosa (Salad Bowl), Veneranda, Brava, Cerbiatta (Catalonha), Itapua Super, Itaúna Prisée, Simpson and Vitória de Verão were used. The experiment was conducted to ensure the accuracy of the comparisons. The variables analyzed were: Germination, emergence, first germination and emergency counting, mean germination and emergency time, mean germination and emergence velocity, germination and emergency uncertainty index, germination and emergency synchrony, and relative frequency of germination and emergency. In order to obtain the emergency data, it was necessary to use a refrigerated room to give optimal conditions for the seeds and in the initial stage, an acclimatization for a salable development of newly emerged seedlings. For experimental design, completely randomized (CRD) was used for laboratory conditions and randomized blocks (RB) for the field, with four replicates of 25 seeds per treatment. The data were submitted for analysis of variance (ANOVA) and the means were compared by the Tukey test at 5% probability. The analyses were carried out using SISVAR software 5.6. Cultivar Itaúna obtained the best results in physiological quality evaluations, being recommended for planting in regions of Northeastern Brazil.

Key words: *Lactuca sativa* L., germination, emergence.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) belongs to the family Asteraceae, being one of the vegetables of greater expression in the world. Brazil is a respectable producer and consumer of lettuce, both in “*in natura*” and processed salads. Every year, the interest in the consumption of this vegetable grows throughout the

country, increasing the areas of planting for different regions (Fonseca, 2016).

In Brazil, lettuce is the third most produced vegetable, occupying around 90,000 ha and moving billions of reais annually, being the hardwood vegetable of greater value, both in quantity and in commercialized price (ABCSEM,

2012). Second, according to the Brazilian Institute of Geography and Statistics (IBGE) data from 2006, the state of Alagoas, one of the most productive in the northeast region, was responsible for the production of 345 tons.

Its cultivation is usually practiced by family farming, employing a large number of labor in the field. It has been cultivated in different times and places, in different soil and climatic conditions, and during the most critical period of the culture (which is the germination and seedling emergence), the producer has not always full control of these conditions (Araujo et al., 2010).

Usually, the production is impaired in some regions of Brazil due to the occurrence of high temperatures, being one of the main problems, the fact that the high temperature interferes negatively in the process of seeds germination (Fonseca, 2016). The optimum temperature for germination of lettuce seeds is around 20°C. Several studies, in addition to the farmers' own experience, have shown that most cultivars do not germinate at higher temperatures, above 28°C. The low germination directly affects nurserymen and producers, since in addition to losing the inputs, the occupation of area for seedlings production and the work, often lose production contracts, in view of not having seedlings or plants at the time of the delivery (Fonseca, 2016).

Research shows that in addition to the environmental factor, there is an important genetic component associated with greater or lesser germination capacity, there being genetic variability for this characteristic, being important to evaluate each cultivar to be used as being different from the others, which may present different results of other goods looking visually (Argyris et al., 2008; Nascimento et al., 2012).

Due to the increase of the demand of this vegetable, it is necessary to evaluate the quality of the seeds that are commercialized in the state of Alagoas. The acquisition of quality seeds is a crucial step for producers to succeed in their activity (Marcos Filho, 2015), where seeds adapted to the region and with a minimum of satisfactory vigor allow farmers to earn enough to keep their families, enabling them to remain in the activity without the need to purchase new lands, reducing the rural exodus and fixing the man in the field.

For the state of Alagoas there is no cultivar specifically developed, it is common to use cultivars that are indicated for other regions, knowing that there is a risk of losing productivity because it is not giving the ideal conditions for the plant to express their total genetic potential. The objective of this work was to evaluate the

physiological potential of different cultivars of lettuce.

MATERIALS AND METHODS

Localization

The work was developed in the Laboratory of Plant Propagation, Center of Agricultural Sciences (CECA), Federal University of Alagoas (UFAL), Rio Largo, AL, Brazil.

Obtaining cultivars

Seeds of ten cultivars of curly lettuce were purchased from two companies: Feltrin and Isla. The used cultivars were the following: Cinderella, Mimosa (Salad Bowl), Monica SF 31 and Veneranda, coming from Feltrin and Brava, Cerbiatta (Catalonha), Itapuã Super, Itaúna Prisée, Simpson and Summer Victory, from Isla.

Water content

For the determination of the water content of the seeds, the greenhouse method was used at $105 \pm 3^\circ\text{C}$ for 24 h, as prescribed by the Rules for Seed Analysis (Brasil, 2009). This determination was made, at the time of installation of the tests, using two samples of 1 g of seeds.

Asepsis

Asepsis of the seeds was carried out by immersion in 70% alcohol for 1 min, followed by washing in running water.

Germination

The seeds were placed to germinate between two sheets of paper towel previously moistened with water volume equivalent to 2.5 times the weight of the dry paper (Brasil, 2009), in transparent plastic boxes (12.0 × 7.0 × 3.5 cm), in a germination chamber type BOD, regulated at a temperature of 20°C.

The seeds that gave normal seedlings germinated, with all their essential structures, showing in this way the potential to continue their development and produce normal plants, when grown under favorable conditions (Brasil, 2009). The daily germinated seed counts were carried out at the same time, for seven days, with the substrate being re-wetted when necessary.

Emergency

For the emergency, trays of 200 cells filled with the commercial substrate of earthworm humus were used, which were subdivided into 4 blocks of 25 (twenty five) cells for each cultivar. The sowing was done with the help of a template of 1 cm for the opening of the pit and 3 seeds were packed per cell.

At the end of the planting, the trays were conditioned in a

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refrigerated room to respond to a physiological requirement of the lettuce, where the temperature was maintained close to 20°C. With the aid of a sprayer, the substrate was maintained with humidity close to field capacity. After the initial emergence, the seedlings were submitted to acclimatization, and on the 6th post-planting day they were taken to greenhouse, where they remained until the end of the experiment. The counts were made daily after the first emergency count, on the 3rd day after sowing, for 14 days, being done at the same time.

Variables analyzed

Germination and emergency

$$g_i = (\sum_{k=1}^k n_i / N) \times 100,$$

where n_i is the number of germinated seeds/seedlings emerged at time i and N the total number of seeds placed to germinate/emerge (Labouriau, 1983; Carvalho et al., 2005).

First count germination/emergence

This was carried out in conjunction with the germination and emergency test, computing the percentage of normal seedlings obtained from the fourth day for germination and the third day for emergence after the tests were installed.

Average germination and emergency time

$t = \sum_{k=1}^k (n_i t_i) / \sum_{k=1}^k n_i$, being t_i : time from the beginning of the experiment to the i th observation (days or h); n_i : number of germinated seeds/seedlings emerged at time i (corresponding number or i th observation); k : last day of germination/emergency (Czabator, 1962).

Average speed of germination and emergency

$v = 1/t$, being t the mean time of germination/emergency (Santana and Ranal, 2004).

Relative germination frequency

$F_i = n_i / \sum_{k=1}^k n_i$, being n_i the number of germinated seeds/seedlings emerged per day and $\sum n_i$ the total number of germinated seeds/emerged seedlings (Labouriau and Valadares, 1976).

Uncertainty index

$U = -\sum_{k=1}^k F_i \log_2 F_i \approx F_i = n_i / \sum_{k=1}^k n_i$, being F_i : relative frequency of germination/emergence; n_i : number of germinated seeds/seedlings emerged at time i (corresponding number or i th observation); k : last day of germination/emergency (Labouriau and Valadares, 1976; Labouriau, 1983).

Synchronicity Index

$Z = \sum C_{n1,2} / N \approx C_{n1,2} = n_i(n_i - 1) / 2$; $N = \sum n_i(\sum n_i - 1) / 2$, being ' $C_{n1,2}$ ' the combination of germinated seeds/seedlings emerged in i the i th

time and n_i the number of germinated seeds/seedlings emerged in time i (Primack, 1980).

Statistical analyses

The experimental design was completely randomized (CRD) for laboratory conditions and randomized blocks (RB) for field, with four replicates of 25 seeds per treatment. The data were submitted for analysis of variance (ANOVA) and the means were compared by the Tukey test at 5% probability. The analyses were performed with the aid of SISVAR software 5.6 (Ferreira, 2011).

RESULTS AND DISCUSSION

In greenhouse, the mean temperature during the period of the experiment was 28°C. The maximum and minimum temperature did not exceed 30.1 and 22°C, respectively and the approximate mean relative humidity of 50.3% was maintained (Figure 1). These temperatures help the germination, emergence and development of lettuce seedlings (Brasil, 2009). The rains were not sufficient to supply the water needs of the crop, requiring three irrigation shifts.

The values of water contents of the seeds of the different cultivars ranged from 5.5 to 6.4% (Table 1), close to those reported by Barbosa et al. (2011) in different lots of lettuce seeds. It is important to note the importance of having the water content among the tested cultivars with the lowest possible variation, since when variations occur between the values of water content, there may be changes in germination and emergence that will accelerate the deterioration process, and formation of products that cause immediate damages, such as free radicals, masking the final result, as described by Marcos Filho (2015).

For all cultivars, the germination percentage was higher than the established standard for the marketing of lettuce seeds (80%), except the cultivars Itapuã (60%) and Mimosa (65%) (Table 2). The results of the germination and emergence tests indicated statistical differences between cultivars, with Itaúna being superior when compared with the others (Table 2), indicating a high physiological potential of the seeds of this plant. However, the results of these tests do not guarantee similar post-performance, even when germination and emergence are high, since seed performance depends on their physiological potential and environmental conditions (Melo Junior et al., 2018).

The optimum temperature range, for most species, is between 20 and 30°C (Marcos Filho, 2015). For the seeds in question, the temperatures of approximately 20°C provided the largest number of seeds germinated in the first count.

The physiological potential of the seeds can be evaluated by the germination test, conducted under

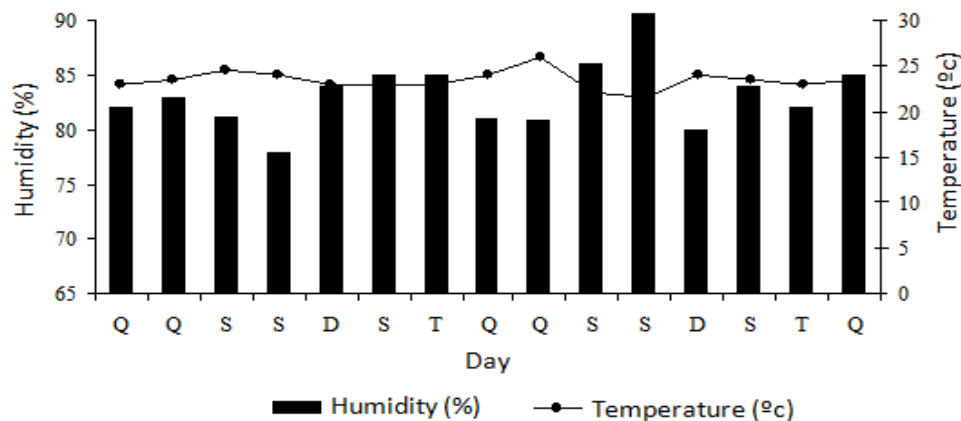


Figure 1. Daily averages of temperature and humidity occurred in Rio Largo (AL) from August 11 to 25, 2018 (CECA/UFAL, 2018).

Table 1. Water content (%) of different cultivars of crisp lettuce (CECA/UFAL, 2018).

Itapuã	Veneranda	Itaúna	Simpson	Monica	Vitória de Verão	Cerbiatta	Cinderella	Mimosa
6.4	6.3	5.5	5.8	5.9	6.2	6.1	6.0	6.2

highly favorable conditions of temperature, humidity and substrate, thus allowing the maximum potential for germination, not reflecting the behavior of the species in the field and therefore not detecting advanced stages of growth deterioration (Larré et al., 2009).

The cultivars Veneranda, Simpson, Mônica, Vitória de Verão and Cerbiatta were not differentiate statistically from each other for the first germination count, however they differed from Itaúna, which was superior (Table 2). The absolute values observed in this test were similar to the order verified in the germination test, since the two tests are conducted concomitantly; they indicate the performance of a population and under totally favorable conditions that can benefit lots of medium vigor. This test was also able to differentiate cultivars as a function of vigor in carrot (Spinola et al., 1998) and cucumber seeds (Bhering et al., 2000). In the first emergency count (PCE) (Table 2), the cultivar Itaúna also showed higher physiological potential, thus differing from the other cultivars analyzed. The PCE test often better expresses the differences in emergency velocity, but Valentini and Piña-Rodrigues (1995) emphasized that this test has a reduced efficiency in detecting small differences in force.

The first count test has generally been used as a vigor test due to its simplicity and to be conducted along with the germination test (Carvalho and Nakagawa, 2012). This test, despite being considered important for evaluating seed germination velocity, because it is not very labor intensive, and because it does not require specific equipment or infrastructure (Bhering et al., 2000),

could have its results affected by the fact that the temperature of 20°C be ideal for seed germination. Studies conducted with other species, such as cotton (Torres, 1998) and chili (Torres and Minami, 2000), also indicated low sensitivity of the first-count test to stratify seed cultivars, especially when differences in vigor are relatively narrow.

Regarding seed vigor (Table 3), indirectly measured by mean germination time (TMG), mean time of emergence (TME), mean germination velocity (VME) and mean velocity of emergence (VME), it was noted that the best results were obtained with the cultivar Itaúna, although it is not different from some cultivars in some variables. Silva et al. (2014) studying the germination of seeds stated that the speed of germination is linearly dependent on temperature, being a good index to evaluate the occupation of a species in a given environment, taking advantage of favorable environmental conditions. Oliveira et al. (2014) say that temperature is an important factor in seed germination, influencing total germination, emergence and seed vigor, as measured by the speed and the mean germination, also by emergency time.

The germination speed can be used to identify cultivars with a faster germination, indicating a higher physiological potential (Santana and Ranal, 2004). Lettuce seeds, in general, present a more homogeneous behavior around the mean time. This result corroborates the rapid germination of most seeds in the early days. According to Nascimento and Pereira (2007) the germination speed is a characteristic that can be used to establish the

Table 2. Germination (G), emergence (E), first germination (PCG) and emergency (PCE) counts of seeds and seedlings of different cultivars of crisp lettuce (CECA/UFAL, 2018).

Grow crop	G (%)	E (%)	PCG (%)	PCE (%)
Itapuã	60 ^c	62 ^d	45 ^d	6 ^{de}
Veneranda	89 ^b	60 ^d	94 ^b	4 ^e
Itaúna	100 ^a	98 ^a	100 ^a	34 ^a
Simpson	86 ^b	81 ^c	84 ^b	16 ^c
Monica	96 ^b	90 ^b	92 ^b	28 ^b
Vitória de Verão	97 ^b	88 ^b	95 ^b	17 ^c
Cerbiatta	89 ^b	57 ^d	84 ^b	0 ^f
Cinderella	85 ^b	68 ^d	66 ^c	8 ^d
Mimosa	65 ^c	41 ^e	15 ^e	8 ^d
Value of "F"	112.46**	15.35**	111.24**	253.29**
CV (%)	8.16	10.15	9.95	10.00

Means followed by the same lowercase letter in the column do not differ from each other to a 5% probability by the Tukey test. **Significant at the 1% probability level.

Table 3. Average germination time (TMG), of emergency (TME), average speed of germination (VMG) and of emergency (VME) of seeds and seedlings of different cultivars of crisp lettuce (CECA/UFAL, 2018).

Grow crop	TMG (days)	TME (days)	VMG (days ⁻¹)	VME (days ⁻¹)
Itapuã	4.4 ^a	5.4 ^d	0.22 ^b	0.31 ^{bc}
Veneranda	4.0 ^a	5.7 ^e	0.25 ^a	0.31 ^{bc}
Itaúna	4.0 ^a	3 ^a	0.25 ^a	0.15 ^a
Simpson	4.1 ^a	3.3 ^{ab}	0.24 ^a	0.22 ^a
Monica	4.0 ^a	3.3 ^{ab}	0.24 ^a	0.17 ^a
Vitória de Verão	4.0 ^a	3.3 ^{ab}	0.25 ^a	0.18 ^a
Cerbiatta	4.0 ^a	5.7 ^e	0.24 ^a	0.33 ^c
Cinderella	4.3 ^a	4.2 ^c	0.23 ^{ab}	0.25 ^{ab}
Mimosa	5.4 ^b	4.5 ^c	0.18 ^c	0.30 ^{bc}
Valor de "F"	170.78**	24.17**	322.29**	14.12**
CV (%)	5.63	10.16	4.05	13.01

Means followed by the same lowercase letter in the column do not differ from each other to a 5% probability by the Tukey test. **Significant at the 1% probability level.

emergence index in the field or greenhouse, and higher velocities would minimize the effect of possible adverse conditions after sowing. For lettuce cultivation this is very important, since high temperatures during the first hours of germination can lead to the seeds entering thermoinhibition and/or in thermodormity, affecting the establishment of the culture (Bewley and Black, 1994; Nascimento, 2003).

The analysis of the results of uncertainty (U) and synchrony of germination and emergence (Z) of lettuce seeds (Table 4) allowed the confirmation that the cultivar Itaúna was significantly superior to the others. Carvalho

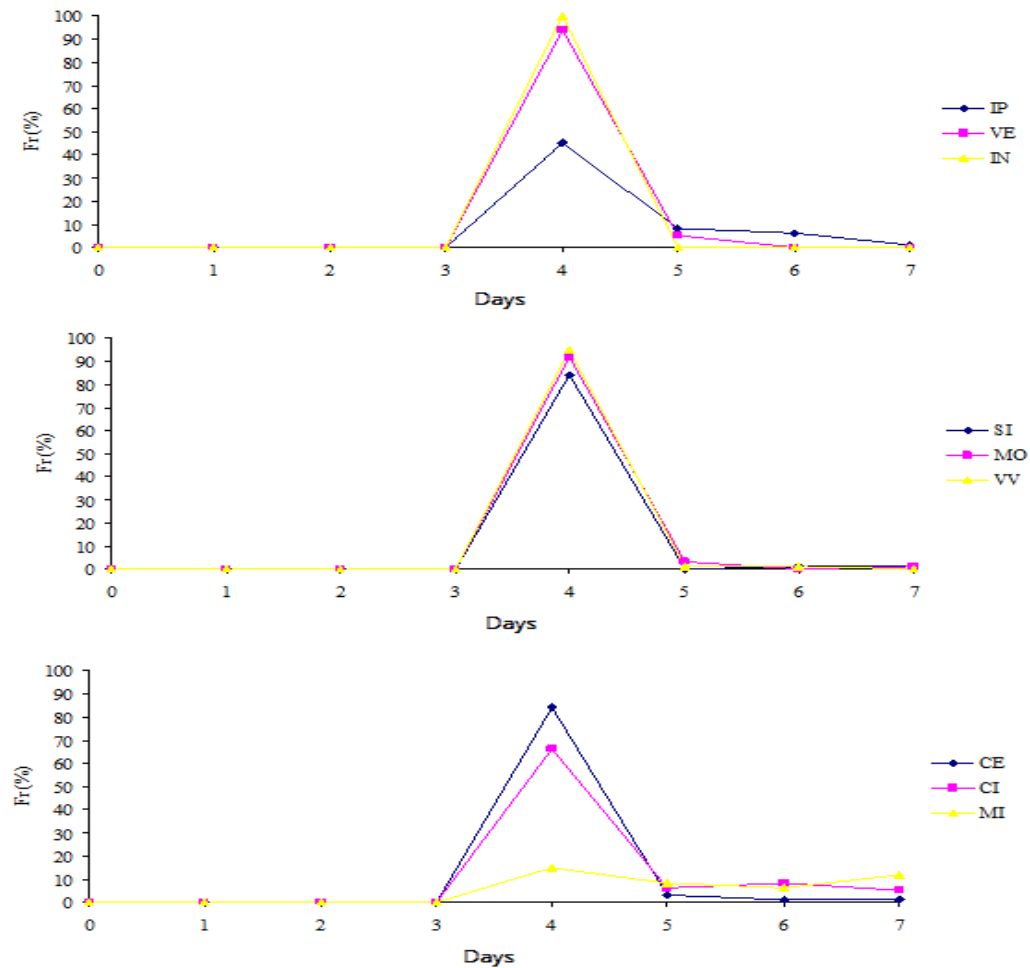
et al. (2015) working with radish seeds used the germination synchrony to evaluate different cultivars. It is emphasized that the increase of the synchrony expressed to the physiological homogeneity of the seeds at the moment of germination (Conserva, 2006), that is, the closer to the result, the more uniform the germination process.

By the values of uncertainty (informational entropy), it was observed that the cultivars caused frequencies with few peaks (Figure 2) or probable unimodal distribution of the relative frequency, that is, the most concentrated germination in time. This result shows that the higher the

Table 4. Uncertainty index (U) and synchrony index (Z) of germination and emergence of cultivars of crisp lettuce (CECA/UFAL, 2018).

Grow crop	U germination (bits)	U emergency (bits)	Z germination	Z emergency
Itapuã	1.1763 ^c	2.3451 ^c	0.5771 ^b	0.2045 ^{de}
Veneranda	0.2813 ^b	2.4377 ^c	0.9608 ^a	0.1504 ^{ef}
Itaúna	0.0001 ^a	1.6060 ^a	1.0000 ^a	0.5483 ^a
Simpson	0.4822 ^b	1.7391 ^{ab}	0.8932 ^a	0.3545 ^b
Monica	0.4011 ^b	1.6237 ^a	0.9181 ^a	0.3618 ^b
Vitória de Verão	0.3063 ^b	1.6675 ^a	0.9512 ^a	0.3599 ^b
Cerbiatta	0.4421 ^b	2.6691 ^c	0.9092 ^a	0.1313 ^f
Cinderella	1.1348 ^c	2.2019 ^{bc}	0.6249 ^b	0.2658 ^c
Mimosa	1.5082 ^d	2.3238 ^c	0.3098 ^c	0.2571 ^{cd}
Value of "F"	127.33**	16.15**	31.61**	100.97**
CV (%)	16.04	9.61	10.27	8.27

Means followed by the same lowercase letter in the column do not differ from each other to a 5% probability by the Tukey test. ** Significant at the 1% probability level.

**Figure 2.** Relative frequencies of seed germination of different cultivars of crisp lettuce. (IP: Itapuã, VE: Veneranda, IN: Itaúna, SI: Simpson, MO: Monica, VV: Vitória de verão, CE: Cerbiatta, CI: Cinderella e MI: Mimosa) (CECA/UFAL, 2018).

level of organization of the process, the greater the germination speed (Table 4).

The accumulated percentages of germination of the lettuce seeds, during the 7 days of experiment, indicate that the germination of the cultivars Itaúna, Simpson, Monica, Vitória de Verão and Cerbiatta began on the fourth day after the installation of the experiment, while in the other the germinative process started after the fourth day (Figure 2). It can be observed that the species under study have a short period of germination, with the distribution of the germination process in a few days and that the frequency of germination is associated with the synchronization index of germination, as reported by Bufalo et al. (2012).

Conclusion

The cultivars Itaúna, Simpson, Monica and Vitória de Verão obtained the best physiological potentials, being indicated for regions of Northeast Brazilian.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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