Accelerated aging of *Celosia argentea* and *Celosia cristata* seeds[1]

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ABSTRACT

Celosia argentea L. and *Celosia cristata* L. are plants that are differentiated by the intensity and color of their flowering, and can be used as garden or cut-flower, with characteristic propagation by seeds produced in large quantities. The present study aimed to evaluate the physiological and sanitary quality of *Celosia argentea* and *Celosia cristata* seeds subjected to the accelerated aging test. The experiment was carried out in October 2016, using a completely randomized design, in a 2 × 6 factorial scheme (two temperatures: 41 and 45 ºC and six periods of heat exposure: 0 (control), 24, 48, 72, 96 and 120 h), with four replicates of 50 seeds, for the two species of cockscomb (*C. argentea* and *C. cristata*). The seed lots of the two species of celosia are from the crops in the year 2012 and were stored in a cold chamber (15 ºC and 40% RH), with an average moisture content of 11% and a mean germination of 98%. After the accelerated aging test, the physiological and sanitary qualities of the seeds of the two species of celosia were evaluated. We conclude that the accelerated aging proved to be effective for the evaluation of vigor, germination and emergence in the species field, when submitted to temperatures of 41 and 45 ºC up to 120 h.
Keywords: floriculture, ornamental seeds, vigor.

RESUMO

Envelhecimento acelerado de sementes de *Celosia argentea* e *Celosia cristata*

Celosia argentea L. e *Celosia cristata* L. são plantas que se diferenciam pela intensidade e coloração de seu florescimento, podendo ser utilizadas como forração-de-jardim ou flor-de-corte, com propagação característica por sementes produzidas em grande quantidade. O presente trabalho objetivou avaliar a qualidade fisiológica e sanitária de sementes de *Celosia argentea* e *Celosia cristata* submetidas ao teste de envelhecimento acelerado. O experimento foi realizado em outubro de 2016, utilizando delineamento inteiramente casualizado, em esquema fatorial 2 × 6 (duas temperaturas: 41 e 45 ºC e seis períodos de exposição ao calor: 0 (controle), 24, 48, 72, 96 e 120 h), com quatro repetições de 50 sementes, para as duas espécies de celosia (*C. argentea* e *C. cristata*). Os lotes de sementes das duas espécies de celosias são oriundos dos cultivos, no ano de 2012 e, foram armazenados em câmera fria (15 ºC e 40% UR), com grau de umidade médio de 11% e germinação média de 98%. Após a realização do teste de envelhecimento acelerado foi avaliada a qualidade fisiológica e sanitária das sementes das duas espécies de celosias. Conclui-se que o envelhecimento acelerado demonstrou ser eficiente para avaliação do vigor, de germinação e emergência no campo destas espécies, quando submetidas a temperaturas de 41 e 45 ºC por até 120 h.
Palavras-chave: floricultura, sementes ornamentais, vigor.

1. INTRODUCTION

The Brazilian floriculture cultivates approximately three thousand varieties among cut flowers, potted plants and ornamental plants, with high demand in visual aesthetic quality and phytosanitary (MENEGAES et al., 2015; JUNQUEIRA and PEETZ, 2017). Among the cut flowers, the ones propagated by seeds as the species of *Celosia argentea* L. and *Celosia cristata* L. stand out by the exoticism of inflorescences and durability post-harvest.

The species of cockscomb belong to Amaranthaceae family and come from Asia, *C. argentea* is known popularly as plumed cockscomb because the inflorescence is in form of feather and C. *cristata* is popularly known as cockscomb because the inflorescence is in form of velvety fan, with the tops similar to the comb of the cock. Both species of celosia present upright size, little branched, succulent stem, 30 to 90 cm of height, leaves are green and slightly reddish, with inflorescences in red, yellow or white-cream color and with characteristic propagation by seeds produced in large quantity. The inflorescences in spike produce fruits of pixidio type, dehiscent attached to the inflorescence with round seeds of blackened color (BELLÉ, 2000; LORENZI, 2013).

The species of cockscomb, of annual crop, flourish in summer and in autumn, producing a large quantity of seeds per plant. However, the quality of these seeds depends directly on the crop management adopted, which is going to influence the percentage and speed of germination (FERREIRA et al., 2012). The seed is an important

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agricultural input and vital to the success or failure of crop, because it contains the productive potentialities of the plant and the preservation of genetic resources. In which the genetic, physical, physiological and sanitary attributes determine the capacity of seed to originate plants of high productivity and, throughout the time, these attributes are modifying themselves, being necessary the preservation of these qualities, specially the vigor and the longevity (MENTEN and MORAES, 2010).

The quality of the seeds can be analyzed by several tests; among them we highlight the germination standard test and the emergence at field test. The first is conducted in laboratory under favorable conditions that allow the maximum expression of capacity of a seed lot, the second is performed at field and when in great conditions predicts more adequately the qualitative performance of the seed lot tested (BERTOLIN et al., 2011). Nevertheless, both tests can overestimate the values of germination and emergence of seedlings, and in this context, it is necessary to perform vigor tests in seeds under adverse conditions. For example, the accelerated aging test, which uses high temperatures and elevated relative humidity of air, for a period of time, what provokes deleterious effects in seeds because it triggers and intensify their metabolic activities (MARCOS-FILHO, 2015). The efficiency of this test allows, also, evaluating the storage potential of seeds, because the difference presented by the same when submitted to the aging test indicate their sensibility to deterioration (MENEZES et al., 2008; SILVA et al., 2010).

Thus, the objective of this present work was to evaluate the physiological and sanitary quality of seeds of *Celosia argentea* and *Celosia cristata* submitted to the accelerated aging test.

2. MATERIAL AND METHODS

The experiment was carried out in the period from October, 2016, we used the entirely randomized design, organized in factorial scheme 2 x 6 (two temperatures and six periods of exposure to heat), with four repetitions of 50 seeds, for two species of cockscomb (*C. argentea* and *C. cristata*). The two temperatures were of 41 and 45 ºC and, the six periods of exposure to heat were from 0 (control), 24, 48, 72, 96 and 120 h. The seed lots of the two species of cockscomb (*Celosia argentea* L. and *Celosia cristata* L.) have come from crops, in the year of 2012, being collected in the month of March.

The storage of lots was in cold chamber (15 ºC e 40% UR), in packages of Kraft paper, with average degree of humidity of 11% and average germination of 98%, from the harvest date. The germination percentage of seeds in the beginning of the experiment can be verified in the time zero hour of exposure to heat, which was of 92% and 93% for species of *C. argentea* and *C. cristata,* respectively.

Previously, the installation of the accelerated aging test was determined by the mass of a thousand seeds by methodology of the manual of Rules for Analysis of Seeds (BRASIL, 2009a). For the species of *C. argentea* and *C. cristata* the masses of a thousand seeds were of 0.76 and 0.90 g, respectively.

The qualities of seeds of the two species were evaluated in relation to their physiological and sanitary characteristics after submission to the accelerated aging test. For carrying out this test, we used boxes of crystal polystyrene (gearbox) in the dimensions of 11.5 x 11.5 x 3.5 cm, with the metallic screen and on the screens we used two sheets of filter paper to give support to the seeds, which were distributed, in a single layer with approximately 5 g of seeds for each period of exposure to heat. For obtaining of the relative humidity of air of 100% in the interior of the boxes, it was added 40 mL of distilled water. The gearbox boxes were sealed and maintained in an air circulating greenhouse at temperatures and periods of time aforementioned (MENEZES et al., 2008; BERTOLIN et al., 2011).

After each time, the seeds were submitted to the evaluation of degree of humidity using for each period of aging four sub-samples of 5 g of seeds which were removed for evaluation of degree of humidity, carried out by the greenhouse method at 105 ± 3 ºC for 24 h (BRASIL, 2009a); germination standard test (TPG) in gearbox boxes prepared with three sheets of filter paper moistened with distilled water corresponding to 2.5 times their weight, with four repetitions of 50 seeds and accommodated in germination chamber of BOD (box organism development) type at 25 ºC with photoperiod of 24 h. The evaluation of germination 14 DAS (days after sowing) and, the results expressed in percentage of normal planting (BRASIL, 2009a); first count of germination (vigor), performed together with TPG, the percentage of normal seedlings was determined 5 DAS of TPG (BRASIL, 2009a); germination speed index (IVG), carried out together with TPG, with daily evaluations according to the methodology described by Maguire (1962); emergence at field using four repetitions of 50 seeds were sown in lines of 1m, with space between them of 0.2 m and in grooves of 0.03 m of depth, the evaluation of emergence was performed 14 DAS, with results expressed in percentage of emergence (BRASIL, 2009a); length and mass of seedling, were performed with four repetitions of 20 seeds and, maintained in the same condition of the germination standard test. 5 DAS, we measured the length of the aerial part and radical root of ten normal seedlings of each repetition and, in the sequence, we verified the fresh mass of seedlings in precision scale of 0.001 g, the determination of dry mass occurred through drying of these material in forced ventilation greenhouse at 65 ± 5 ºC for 48 h (NAKAGAWA, 1999); sanitary test in filter paper, carried out through the incubation in substrate of paper (Blotter Test), with four repetitions of 50 seeds. The germination was inhibited by the freezing method for 24h; afterwards, the seeds remained in BOD for 5 days with photoperiod of 12 h of light and temperature at 20 ± 1 ºC. The percentages of infested seeds and identification of phytopathogens in genus level were evaluated in magnifying glass (microscope stereoscope) (BRASIL, 2009b).

The data expressed in percentage was transformed in arc-sine $\sqrt{x/100}$ and, the analysis of variance (ANOVA) and Tukey test, at the level of 5% of error, performed with the help of statistical program SISVAR (FERREIRA, 2011). The correlation of Pearson was performed between the degree of humidity of seeds and the first germination count, the germination of normal seedlings, the germination speed index and the emergence at field of the cockscomb seeds submitted to the accelerated aging test.

3. RESULTS AND DISCUSSION

There was a significant interaction between the temperature factors and the periods of exposure to heat. We verified that the species of *C. argentea* and *C. cristata* obtained similar performance in all the tests.

The degree of initial humidity was of 11.51% and 11.62% for the species of *C. argentea* and *C. cristata*, respectively (Table 1). We observed a difference in the degree of humidity between the temperatures of 41 and 45 ºC, for both the species. There was also a percentage increase in the degree of humidity of these seeds according to the period of exposure to heat. In the period of 24 h of exposure to heat, for both tested temperatures, there was the greatest change in degree of humidity for both species, in view of the difference of humidity between the seed and the environment to which it was submitted. After this period there was a tendency to stabilization of seeds hydration.

Table 1. Degree of humidity, first germination count, germination of normal seedlings, germination speed index, seedling dry mass and length, and emergence to the field of cellulose seeds submitted to the accelerated aging test.

Hours	*Celosia argentea*		*Celosia cristata*		*Celosia argentea*		*Celosia cristata*	
	41 ºC	45 ºC	41 ºC	45 ºC	41 ºC	45 ºC	41 ºC	45 ºC
	Degree of humidity (%)				First germination count (%)			
0	11.5 Ad*	11.5 Ad	11.6 Ab	11.6 Ac	92 Aa	92 Aa	93 Aa	93 Aa
24	20.1 Ac	18.0 Bc	23.8 Aa	18.1 Bb	70 Bb	86 Aab	69 Ab	82 Ab
48	24.6 Ab	21.0 Bb	23.8 Aa	19.2 Bb	70 Bb	82 Aab	72 Ab	57 Ac
72	25.9 Bb	25.4 Aa	23.5 Aa	19.9 Bb	72 Ab	71 Ab	71 Ab	58 Ac
96	27.5 Aa	25.1 Ba	23.4 Aa	20.0 Ba	72 Ab	63 Bc	70 Ab	58 Ac
120	27.8 Aa	25.4 Ba	23.4 Aa	23.6 Aa	72 Ab	60 Bc	68 Ab	21 Bd
CV (%)	1.98		2.74		9.85		8.56	
	Germination of normal seedlings (%)				Germination speed index			
0	92 Aa	92 Aa	93 Aa	93 Aa	75.83 Aa	75.83 Aa	71.23 Aa	71.23 Aa
24	81 Ab	86 Ab	82 Ab	84 Ab	57.66 Ab	50.71 Ab	60.81 Aab	59.25Aab
48	80 Ab	84 Aa	75 Ab	60 Bc	47.99 Abc	49.48 Ab	58.38 Aab	52.19 Ab
72	77 Ac	72 Ac	74 Ab	73 Ac	43.05 Abc	41.28 Abc	56.92 Aab	45.92 Abc
96	76 Ac	70 Ac	71 Ab	65 Ac	42.63 Abc	31.08 Bcd	49.19 Abc	30.67 Bc
120	75 Ac	70 Ac	69 Ac	27 Bd	39.98 Ac	20.23 Bd	38.58 Ac	12.44 Bd
CV (%)	7.51		8.27		8.82		8.15	
	Root length (cm)				Aerial part length (cm)			
0	2.6 Aa	2.6 Aa	2.4 Aa	2.4 Aa	1.7 Aa	1.7 Aa	1.5 Aa	1.5 Aa
24	2.5 Aa	2.5 Aa	2.2 Aa	2.0 Aa	1.6 Aa	1.6 Aa	1.5 Aa	1.4 Aa
48	2.4 Aa	2.5 Aa	2.1 Aa	1.9 Aa	1.6 Aa	1.6 Aa	1.2 Aa	1.4 Aa
72	2.4 Aa	2.2 Aa	1.9 Aa	1.6 Aa	1.5 Aa	1.4 Aa	1.2 Aa	1.2 Aa
96	2.2 Aa	1.9 Aa	1.9 Aa	1.6 Aa	1.5 Aa	1.4 Aa	1.2 Aa	1.1 Aa
120	2.0 Aa	1.9 Aa	1.9 Aa	1.6 Aa	1.5 Aa	1.3 Aa	1.1 Aa	0.9 Aa
CV (%)	9.02		7.88		14.04		6.98	
	Seedling dry mass (mg seedling^{-1})				Emergence at field (%)			
0	0.642 Aa	0.642 Aa	0.606 Aa	0.606 Aa	90 Aa	90 Aa	94 Aa	94 Aa
24	0.610 Aa	0.621 Aa	0.603 Aa	0.562 Aa	82 Ab	79 Ab	86 Ab	83 Ab
48	0.604 Aa	0.601 Aa	0.597 Aa	0.511 Aa	80 Ab	78 Ab	83 Ab	72 Ac
72	0.596 Aa	0.595 Aa	0.568 Aa	0.499 Aa	75 Aa	70 Ac	78 Abc	66 Ac
96	0.511 Aa	0.540 Aa	0.560 Aa	0.483 Aa	70 Ac	70 Ac	73 Ac	62 Ac
120	0.486 Aa	0.499 Aa	0.555 Aa	0.441 Aa	70 Ac	70 Ac	65 Ad	50 Ad
CV (%)	15.34		23.57		7.99		8.02	

* Averages followed by the same capital letter in the row and the lower column comparing temperatures and periods of exposure to heat, respectively, do not differ at the 5% level of error by the Tukey test. CV = coefficient of variation.

Bertolin et al. (2011) observed in the accelerated aging test with different lots of bean (*Phaseolus vulgaris* L.) that there was an increase in the seeds degree of humidity according to time of exposure to heat, with negative influence on the germinative percentage. Guedes et al. (2013) reported that in accelerated aging test, the wetting speed of seeds is what determines the intensity of deterioration of the same according to the membrane rearrangement, what leads to anticipation of metabolic triggering of Phase I of three-phase standard described by Bewley e Black (1994).

The seeds with high degree of humidity when in transition between the Phases I and II affect, directly, the Phase III comprehended as germination resulting of intense metabolic processes which triggers the development of embryo originating, thus, a seedling (MARCOS-FILHO, 2015). The high relative humidity of the environment allows the occurrence of initial hydration in seeds in form of water vapor, when in high temperatures can cause damage to the membranes by lixiviation of cellular content, resulting in the increase of deterioration speed and in reduction of germinative potential (SANTOS et al., 2010; MARCOS-FILHO, 2015).

In the physiological parameters observed by germination standard test carried out after the accelerated aging test and the control (0h), in which we verified a reduction in expression of vigor (first germination count) for both the species of celosia in the two temperatures tested, according to the increase of period of heat exposure (Table 1). In the greatest period of heat exposure tested (120 h), we verified that there was a reduction of the vigor potential of *C. argentea* of 92% to 72% and 60% in temperatures of 41 and 45 ºC, respectively and, of *C. cristata* vigor of 93% to 68% and 21% in temperatures of 41 and 45 ºC, respectively. Barbosa et al. (2011) verified in lettuce seeds (*Lactuca sativa* L.) cv. Vera, by accelerated aging test, a reduction of vigor percentage in the period of exposure for 72 h.

The germination of normal seedlings, for both species in temperatures of 41 and 45 ºC followed the same vigor standard, with reduction of percentage of normal seedlings (Table 1). This gradual reduction of germination potential inside the tested temperatures demonstrate that there was a physiological deterioration of seeds, in consequence of the increase of humidity degree, resulting in a decrease of germination with the increase of exposure at the temperatures. These results were similar to the ones observed by Menezes et al. (2008) in the accelerated aging test with seeds of zinnia (*Zinnia elegans* Jacq.) and Bertolin et al. (2011) with different lots of beans.

The emergence at field of seeds of both cockscomb species was similar to the germination in laboratory, corroborating with vigor at first count (Table 1). Bertolin et al. (2011) point out that the emergence test at field can predict adequately the seeds lot quality performance, proving the results obtained in laboratory. Menezes et al. (2007) emphasized the importance of carrying out the tests in laboratory and at field for verifying the physiological quality, under the influence of different environmental conditions.

The accelerated aging test provides conditions that can cause the anticipated deterioration of the physiological processes of seeds resulting in the loss of germinative viability, simulating conditions of storage by long periods (SILVA et al., 2010). The exposure of celosia seeds to high humidity and temperature for different periods of heat demonstrated that these species can be stored by long periods without losing the viability. As in 120 h of exposure to heat *C. argentea* species had a difference of 18.5% and 23.9% in germination percentage, for the temperatures of 41 and 45 ºC, respectively and, *C. cristata* with difference of 25.8% and 70.9% in germination percentage, for the temperatures of 41 and 45 ºC, respectively. And, when taken to field the emergence in the same period of exposure to heat of 120 h, *C. argentea* species presented a difference of 22.2% in emergence percentage at field for both tested temperatures and, *C. cristata* with difference of 30.8% and 46.89% in emergence percentage at field, for the temperatures of 41 and 45 ºC, respectively.

Okusanya (1980) researching the seeds germination of *C. cristata* in different temperatures, verified that the same is inhibited in the range between 15-21 ºC. This indicates that the temperatures, as well as the period of exposure to heat, affect negatively the physiological potential of germination and of emergence at field, however do not block them, reducing only their expression (BEWLEY and BLACK, 1994). Marcos-Filho (2015) says that the deterioration process of seeds depends on the genetic heritage since the membrane rearrangement for the beginning of the germinative three-phase process, added to the degree of humidity and the exposure to heat.

We verified that the germination speed index (IVG) in both cockscomb species was reducing itself according to the increase of period of exposure to heat in the accelerated aging test (Table 1). And, in the greatest period of exposure to the tested heat (120 h), we observed a reduction of IVG of *C. argentea* of 47.2% and 73.3% for both temperatures of 41 and 45 ºC, respectively and, of IVG of *C. cristata* of 45,8% and 82,5% in the temperatures of 41 and 45 ºC, respectively. Barbosa et al. (2011) working with seeds of cauliflower (*Brassica oleracea* L.) cv. Piracicaba submitted to the accelerated aging test verified a reduction of 48.2% in IVG at 38 °C for 72 h.

We observed that the parameters of length and dry mass of seedlings (Table 1) do not differ statistically for both celosia species in the tested temperatures, demonstrating high genetic quality of seeds, and thus it is suggested that they can be cultivated in different environmental conditions.

In Table 2, we observe that the percentage of infested seeds increased according to the increase of the period of exposure to heat, and this performance occurred for the two celosia species. Carvalho and Nakagawa (2000) and Guedes et al. (2013) highlight that the degree of humidity increment in seeds, in view of the conditions in which the accelerated aging test is performed, intensify the respiratory processes and the activity of microorganisms due to the increase of temperature. However, Härter et al. (2014) report the importance of phytopathogens exemption in seeds, because the contamination of the same can cause damage in the future development of seeds in the field.

Among the infested seeds, we observed the incidence of phytopathogens of *Aspergillus* sp., *Fusarium* sp. e *Penicillium* sp. genus, and the greatest incidence registered in the time of exposure to heat of 120 h, for both tested temperatures in the seeds of *C. argentea* and *C. cristata* (Table 2). The conditions of relative humidity of air and temperature are factors that favor the development of phytopathogens in the seeds (SILVA and SILVA, 2000; MENEZES et al., 2008).

Table 2. Sanity test of the celosia seeds submitted to the accelerated aging test.

Hours	*Celosia argentea*		*Celosia cristata*		*Celosia argentea*		*Celosia cristata*	
	41 ºC	**45 ºC**	**41 ºC**	**45 ºC**	**41 ºC**	**45 ºC**	**41 ºC**	**45 ºC**
	Infested seeds (%)				**Incidence of *Fusarium sp.* (%)**			
0	8 Bd*	12 Ad	9 Be	13 Ae	2.8 Be	4.3 Ac	3.2 Ad	4.6 Ad
24	12 Bc	14 Ac	14 Bcd	19 Acd	4.3 Ad	5.0 Ac	5.0 Ad	6.8 Ac
48	14 Bc	16 Abc	20 Ac	22 Ad	5.0 Ad	5.7 Abc	7.1 Ac	7.8 Abc
72	21 Ab	18 Bb	25 Bc	31 Ac	7.5 Ac	6.4 Ab	8.9 Bc	11.0 Ab
96	27 Ab	18 Bb	42 Bb	46 Ab	9.6 Ab	6.4 Bb	15.0 Ab	16.4 Ab
120	41 Aa	38 Ba	61 Aa	63 Aa	14.6 Aa	13.5 Aa	21.7 Aa	22.4 Aa
CV (%)	20.05		19.72		16.92		20.14	
	Incidence of *Aspergillus* sp. (%)				**Incidence of *Penicillium* sp. (%)**			
0	1.3 Ac	2.0 Ab	1.5 Ad	2.1 Ae	3.8 Bd	5.7 Ac	4.3 Bcd	6.2 Ad
24	2.0 Abc	2.3 Ab	2.3 A cd	3.1 Acd	5.7 Ac	6.7 Abc	6.7 Ac	9.1 Acd
48	2.3 Ab	2.6 Ab	3.3 Ac	3.6 Acd	6.7 Ac	7.7 Ab	9.6 Abc	10.5 Ac
72	3.5 Ab	3.0 Ab	4.1 Ac	5.1 Ac	10.1 Ab	8.6 Bb	12.0 Ab	14.8 Ac
96	4.5 Aab	3.0 Ab	6.9 Ab	7.6 Ab	12.9 Ab	8.6 Bb	20.1 Ba	22.0 Ab
120	6.8 Aa	6.3 Aa	10.1 Aa	10.4 Aa	19.6 Aa	18.2 Aa	29.2 Aa	30.2 Aa
CV (%)	18.87		19.59		21.73		15.89	

* Averages followed by the same capital letter in the row and the lower column comparing temperatures and periods of exposure to heat, respectively, do not differ at the 5% level of error by the Tukey test. CV = coefficient of variation.

We verified that *C. cristata* species suffered greater interference of incidence of phytopathogens, mainly, in the period of greatest exposure to heat (120 h) at 45 ºC, in which it was noted the lowest percentage values in vigor (first count), germination and emergence in field. Similar results were observed by Menezes et al. (2008) in seeds of zinnia with the incidence of phytopathogens of *Aspergillus* and *Penicillium* genus, which affected negatively the germination of these seeds, and the authors attributed to the toxin production and the increase of fatty acid rate, what consequently affected the germination. Silva and Silva (2000) verified deterioration in seeds of beans coming from the accelerated aging test because of the incidence of phytopathogens what made it difficult the differentiation between the physiological and sanitary causes involved in the deteriorative process of the same.

In Table 3, we present the coefficient of linear correlation between the degree of humidity of the seeds of cockscomb species and the parameters of the accelerated aging test. We observed that there was positive correlation of *C. argentea* in first count of germination in both temperatures of 41 and 45 ºC for the periods of 0, 24 and 120 h of exposure to heat.

We highlight a strong positive correlation of this species for the germination of normal seedlings at 41 ºC for

72 h of exposure to heat, for the germination speed index at 45 ºC for 48 h and, for the emergence at field at 41 ºC for 24 h and at 45 ºC for 72 h. The coefficient of positive correlation for *C. cristata* species stand out only in first count of germination 45 ºC for 48 h, the germination of normal seedlings at 45 ºC for 48 and 72 h (Table 3).

Table 3. Pearson correlation coefficients between the seed moisture content and the first germination count, germination of normal seedlings, germination speed index and field emergence of the celosia seeds submitted to the accelerated aging test.

Hours	*Celosia argentea*		*Celosia cristata*		*Celosia argentea*		*Celosia cristata*	
	41 ºC	45 ºC	41 ºC	45 ºC	41 ºC	45 ºC	41 ºC	45 ºC
	First germination count				**Germination of normal seedlings**			
0	0.2126	0.2126	-0.2384	-0.2384	0.2126	0.2126	-0.2384	-0.2384
24	0.8938**	0.8293**	0.4749	-0.7100	-0.8279	0.3928	0.1363	-0.6259
48	-0.4464	0.4963	-0.9987	0.7772*	-0.2519	0.7503*	-0.9096	0.8129**
72	0.7445*	-0.2623	-0.9337	0.3125	0.9310**	-0.1203	-0.8631	0.7484*
96	-0.6940	-0.8381	-0.9354	-0.0556	-0.7829	-0.7631	-0.7402	-0.4175
120	0.5479	0.7586*	0.3354	-0.3483	0.2859	0.6887	0.1970	0.1274
	Germination speed index				**Emergence at field**			
0	-0.9325	-0.9325	0.1649	0.1649	0.8486**	0.8486**	-0.7137	-0.7137
24	-0.9299	-0.6812	0.6392	-0.1626	0.9804**	0.6938	-0.5736	-0.7297
48	0.1962	0.9227**	0.6000	0.3273	-0.2386	-0.8974	0.0863	0.5368
72	0.6227	-0.9383	-0.8331	0.6142	-0.7081	0.9233**	0.7213	-0.4465
96	-0.7034	-0.6980	-0.2770	0.4340	-0.8200	-0.1549	-0.4678	-0.5414
120	0.3081	0.8120*	0.2363	-0.3718	-0.0972	-0.6406	-0.3227	0.1682

** and * are significant by the *t* test at 1 and 5% probability, respectively.

In general, we noted that the degree of humidity interfered in seeds germination of both species, promoting a highly negative correlation, mostly in relation to the vigor for the species of *C. cristata.* For Santos et al. (2010) the anticipation of the equilibrium point of seed hydration provoked by the aging test accelerate the metabolic processes causing to them deteriorative stress, observed by the germination speed index of *C. argentea* with negative correlation between the periods of 0 and 24 h of exposure to heat for the two tested temperatures (Table 3).

4. CONCLUSION

The physiological potential of *Celosia argentea* and *Celosia cristata* seeds verified by the accelerated aging test demonstrated to be efficient for evaluation of vigor, of germination and of emergence at field of this species, when submitted to temperatures of 41 and 45 ºC for up 120 h. The conditions, of temperatures and periods of exposure to heat, for performance of accelerated aging test favor the development of phytopathogens about the seeds of the two species of celosia.

AUTHOR CONTRIBUTION

J.F.M. 0000-0001-6053-4221: planning, implementing of the experiment, collection and data interpretation, statistics and writing. **G.F.B.** 0000-0003-0692-0206: planning, implementing of the experiment, collection and data interpretation and writing. **R.A.B.** 0000-0001-6704-417X: planning, statistics and writing. **U.R.N.** 0000-0002-7124-9204: orientation, data interpretation and writing. **T.S.F.** 0000-0002-3425-547X: implementing of the experiment, data interpretation and writing. **R.G.S.** 0000-0002-9888-1082: implementing of the experiment, data interpretation and writing.

REFERENCES

BARBOSA, R.M.; COSTA, D.S.; DE SÁ, M.S. Envelhecimento acelerado de sementes de espécies oleráceas. **Pesquisa Agropecuária Tropical**, v.41, n.3, p.328-335, 2011.

BELLÉ, R.A. **Caderno Didático de Floricultura.** Santa Maria: Curso de Agronomia, UFSM. 2000. 142p.

BERTOLIN, D.C.; SÁ, M.E.; MOREIRA, E.R. Parâmetros do teste de envelhecimento acelerado para determinação do vigor de sementes de feijão. **Revista Brasileira de Sementes***,* Londrina, v.33, n.1, p.104-112, 2011. DOI: 10.1590/S0101-31222011000100012

BEWLEY, J.D.; BLACK, M. **Seeds: Physiology of development and germination**. New York: Plenum Press, 1994. 367p.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Manual de Análise Sanitária de Sementes**. Brasília: MAPA, 2009b. 200p.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Regras para Análise de Sementes**. Brasília: MAPA, 2009a. 395p.

CARVALHO, N.M.; NAKAGAWA, J. **Sementes: ciência, tecnologia e produção**. 4ed. Jaboticabal: FUNEP, 2000. 588p.

FERREIRA, D.F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, v.35, p.1039-1042. 2011.

FERREIRA, E.G.B.S.; MATOS, V.P.; SENA, L.H.M.; SALES, A.G.F.A.; SANTOS, H.H.D. Superação da dormência em sementes de crista de galo. **Ciência Rural**, v.42, n.5, p.808-813, 2012.

GUEDES, R.S.; ALVES, E.D.; OLIVEIRA, L.S.B. Teste de envelhecimento acelerado em sementes de *Chorisia glaziovii* (Kuntze) (Malvaceae). **Bioscience Journal**, v.29, n.2, p.378-385, 2013.

HARTER, L.S.H.; HARTER, F.S.; DEUNER, C.; MENEGHELLO, G.E.; VILLELA, F.A. Salinidade e desempenho fisiológico de sementes e plântulas de mogango. **Horticultura Brasileira**, v.32, n.1, p.80-85, 2014. DOI: 10.1590/S0102-05362014000100013

JUNQUEIRA, A.H.; PEETZ, M.S. Brazilian consumption of flowers and ornamental plants: habits, practices and trends. **Ornamental Horticulture**, v.23, n.2, p.178-184, 2017. DOI: 10.14295/oh.v23i2.1070

LORENZI, H. **Plantas para jardim no Brasil: herbáceas, arbustivas e trepadeiras**. Nova Odessa: Instituto Plantarum, 2013. 1120p.

MAGUIRE, J.D. Speed of germination aid in selection and evaluation for seedling emergence and vigor. **Crop Science**, v.2, n.2, p.176-177, 1962.

MARCOS-FILHO, J. **Fisiologia de sementes de plantas cultivadas**. Londrina: ABRATES, 2015. 650p.

MENEGAES, J.F.; BACKES, F. A.A.L.; BELLÉ, R.A.; BACKES, R.L. Diagnóstico do mercado varejista de flores de Santa Maria, RS**. Ornamental Horticulture**, v.21, n.3, p.291-298. 2015. DOI: 10.14295/oh.v21i3.629

MENEZES, N.L.; GARCIA, D.C.; BAHRY, C.A.; MATTIONI, N.M. Teste de condutividade elétrica em sementes de aveia preta. **Revista Brasileira de Sementes**, v.29, n.2, p.138-142, 2007. DOI: 10.1590/S0101-31222007000200019

MENEZES, V.O.; PEDROSO, D.C.; MUNIZ, M.F.B.; BELLÉ, R.A.; BLUME, E.; GARCIA, D.C. Envelhecimento acelerado em sementes de *Zinnia elegans* Jacq. colhidas em diferentes épocas. **Revista Brasileira de Sementes**, v.30, n.3, p.039-047, 2008.

MENTEN, J.O.; MORAES, M. H. D. Tratamento de sementes: histórico, tipos, características e benefícios. **Informativo ABRATES**, v.20, n.3, p.52-53, 2010.

NAKAGAWA, J. Testes de vigor baseados na avaliação das plântulas. In: KRZYZANOSWKI, F.C.; VIEIRA, R.D.; FRANÇA NETO. J.B. **Vigor de sementes: conceitos e testes**. Londrina: ABRATES, 1999. 218p.

OKUSANYA, O.T. Germination and growth of *Celosia cristata* L., under various light and temperature regimes. **American Journal of Botany**, v.67, n.6, p.854-858, 1980.

SANTOS, F.; TRANI, P.E.; MEDINA, P.F.; PARISI, J.J. Teste de envelhecimento acelerado para avaliação da qualidade de sementes de alface e almeirão. **Revista Brasileira de Sementes**, v.33, n.2, p.322-323, 2011. DOI: 10.1590/S0101-31222011000200015

SILVA, C.B.; PIVETTA, K.F.L.; OLIVEIRA, C.A.V.M.; RODRIGUES, M.A.; VIEIRA, R. D. Teste de envelhecimento acelerado para avaliação do potencial fisiológico de sementes de grama-bermuda. **Revista Brasileira de Sementes**, v.32, n.2 p.102-107, 2010. DOI: 10.1590/S0101-31222010000200012

SILVA, M.A.D.; SILVA, W.R. Comportamento de fungos e de sementes de feijoeiro durante o teste de envelhecimento artificial. **Pesquisa Agropecuária Brasileira**, v.35, n3, p.599-608, 2000.