Scientific Article

Photoblastic and temperatures in the germination of cockscomb seeds[1]

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ABSTRACT

Germination is the result of the triggering of various processes occurred in the seed, which are influenced by the environmental conditions, especially light and temperature. In this way, the objective of the present study was to evaluate the influence of different temperatures and photoblastic on the germination of cockscomb seeds. The experiment was carried out in a completely randomized design, with a 2 x 5 factorial scheme (two lighting regimes and five temperatures), with four replicates of 50 seeds, for two species of cockscomb (*Celosia argentea* L. and *C. cristata* L.). The lighting regimes were with absence (dark continuous) and the presence of light (photoperiod of 24 h), and temperatures were constant at 15, 20, 25, 30 and 35 ºC. The seed lots of the two species of cockscomb were cultivated in 2012 and stored in a cold chamber (15 ºC and 40% RH), with an average moisture content of 11% and a mean germination of 98%. The results of the laboratory tests indicated that the two species of cockscomb presented fast germination in average 2.5 and 4.5 days for the regimes with presence and absence of illumination, respectively, characterizing as neutral photoblastic species. However, it was observed that the temperature is a limiting factor for the germination of the two species of cockscomb, having its optimal thermal range between 20 and 30 ºC

Keywords: *Celosia argentea*, *Celosia cristata*, ornamental seeds.

RESUMO

Fotoblastismo e temperaturas na germinação de sementes de celosias

A germinação é o resultado do desencadeamento de vários processos ocorridos na semente, os quais são influenciados pelas condições ambientais, sobretudo, luz e temperatura. Deste modo, o objetivo do presente trabalho foi avaliar a influência de diferentes temperaturas e fotoblastismo na germinação de sementes de celosias. O experimento foi realizado em delineamento inteiramente casualizado, com esquema fatorial 2 x 5 (dois regimes de iluminação e cinco temperaturas), com quatro repetições de 50 sementes, para duas espécies de celosias (*Celosia argentea* L. e *C. cristata* L.). Os regimes de iluminação foram com a ausência (escuro contínuo) e a presença de luz (fotoperíodo de 24 h), e as temperaturas foram constantes a 15, 20, 25, 30 e 35 ºC. Os lotes de sementes das duas espécies de celosias foram cultivados, 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%. Os resultados dos testes laboratoriais indicaram que as duas espécies de celosias apresentaram germinação rápida em média 2,5 e 4,5 dias para os regimes com presença e com ausência de iluminação, respectivamente, caracterizando-se como espécies fotoblástiscas neutras. Contudo, observou-se que a temperatura é um fator limitante para a germinação das duas espécies de celosias, tendo sua faixa térmica ótima entre 20 a 30 ºC.

Palavras-chave: *Celosia argentea*, *Celosia cristata*, sementes ornamentais.

1. INTRODUCTION

The species from Amaranthaceae family stands out by the exoticism of its inflorescences and the great seeds production per plant, on average of 1,580 kg ha^{-1} (BELLÉ and SPANNENBERG, 1997). Among them, the two species of cockscomb (*Celosia argentea* L. and *Celosia cristata* L.), originating in Asia, have erect size and little branched, from 30 to 90 cm of height, green leaves and slightly reddish, ornamental inflorescences of several colors, among red, yellow and white (LORENZI, 2013). Their inflorescences, of summer cultivation in Rio Grande do Sul, are produced from seeds, which have their physiological and sanitary qualities affected by the adopted management, mainly, in germination (FERREIRA et al., 2012).

The germination is considered a critical phase because it is regulated by physiological processes of seed, besides the environmental conditions, and in relation to the extrinsic factors, each vegetal species requires certain conditions regarding the adequate supply of water, oxygen, temperature, light and depth of seeding for occurrence of germination (MONDO et al., 2010; MARCOS FILHO, 2015). The knowledge about the germinative process of seeds when submitted to different factors is indispensable to establish the ideal conditions for germination of species and thus, optimize the percentage, velocity and

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the uniformity of germination. Among the environmental factors determined for the germination the temperature and light deserve highlight (CARVALHO and NAKAGAWA, 2000; MARCOS FILHO, 2015).

The temperature influence in velocity of germination, as well as in its final percentage, once that the temperature alters the velocity of water absorption and chemical reactions, which are responsible by mobilization of reserves and synthesis of substances used by the seedling (LOPES and FRANKE, 2011). Depending on the ecological characteristics of each species, there is a temperature range where the germination of seeds occurs, and in temperatures that are out of the maximum and minimum limits, the death of embryos can happen and, consequently, the non-germination (TAIZ and ZEIGER, 2009; MARCOS FILHO, 2015). This way, it is necessary to know the effect of the different temperatures and establish great limits of temperature in order to the seeds express their maximum germinative potential in a minor period of time.

The germination of the seeds can also be inhibited or stimulated by the light factor, and the light signals captured by a system of receptor pigments are denominated phytochromes, which are associated to the triggering of metabolic responses to these stimuli (TAIZ and ZEIGER, 2009; ALVES et al., 2011). Thus, there are species of plants, called positive photoblastic, which have the germination of their seeds favored when submitted to the action of light, whereas there are the ones that present their germinative behavior improved with the absence of light and, also, the ones that are indifferent, which do not present light sensitivity.

In this context, the objective of the present study was to evaluate the influence of the different temperatures and photoblastic in germination of cockscomb seeds (*C. argentea* L. and *C. cristata* L.).

2. MATERIAL E METHODS

The experiment was carried out in the period from October 2016 to January 2017, in entirely randomized design, with a 2 x 5 factorial scheme (two lighting regimes and five temperatures), with four replicates of 50 seeds, for the two cockscomb species (*Celosia argentea* L. and *Celosia cristata* L.).

The lighting regimes were with absence (dark continuous) and the presence of light (photoperiod of 2 4h), and the temperatures were constant at 15, 20, 25, 30 and 35 ºC. In relation to the received light, the germinative boxes of gearbox type (crystal polystyrene), were exposed to light produced by four daylight fluorescent lamps (20 W), fixed internally in the door of the germinator of BOD (Box Organism Development) type, which provided a flux density approximately of 0.012 w m^{-2} nm^{-1}, and the absence of light was obtained by the coating of the gearbox boxes with two layers of aluminized paper, and the evaluations of germination of seeds were performed in dark chamber under green light (YAMASHITA and ALBERGUINI, 2011).

The lots of seeds of the two cockscomb species were cultivated and collected in the experimental area of Floriculture Sector of the Crop Science Department, at *Campus* of UFSM, in the year of 2012, and stored, by 55 months, in cold chamber (15 ºC e 40% RH), in packages of Kraft paper, with average degree of humidity of 11% and average germination of 98%.

The seeds of the two species were submitted to determination of mass of one thousand seeds by methodology described in the manual of Rules for Seeds Analysis (BRASIL, 2009); degree of humidity determined by the greenhouse method 105 ± 3 ºC per 24 h, adapted from BRASIL (2009); standard test of germination carried out in gearbox boxes, moistened with distilled water in the proportion of 2.5 times the mass of dry paper. The boxes were maintained in germinator of BOD type, with lighting regime and temperatures aforementioned. The evaluations of germination were performed on 4th and 14th days after sowing (DAS) and, the results expressed in percentage of normal seedlings (BRASIL, 2009); first count of germination (vigor), index of velocity of germination (IVG) and average time of germination in days (TMG) were performed together with the standard test of germination. The vigor was determined in percentage of normal seedlings on 4th DAS (BRASIL, 2009). The IVG and the TMG were determined with daily evaluations until 14th DAS, according the methodology described by Maguire (1962) and Furbeck et al. (1993), respectively; average daily velocity determined by the methodology by Labouriau and Valadares (1976), expressed in Equation 1.

$$V = 1/TMG \quad (1)$$

In which: V = average velocity of germination; TMG = average time of germination; relative frequency of germination determined by the methodology by Labouriau and Valadares (1976), expressed in Equation 2.

$$Fr = ni / \sum_{i=1}^{k} ni \quad (2)$$

In which: Fr = relative frequency of germination; ni = number of seeds germinated per day; Σni = total number of germinated seeds; entropy: index of synchronization of germination determined by the methodology by Labouriau and Valadares (1976), expressed in Equation 3.

$$E = \sum_{i=1}^{k} fi.\log 2.fi \quad (3)$$

In which: E = informational entropy (bits); fi = relative frequency of germination; log2 = logarithm in base 2.

The data expressed in percentage were transformed in arc-sine $\sqrt{x/100}$ and, the variance analysis and comparison of averages by the Tukey test, in level of 5% of error, performed with the help of the statistical program SISVAR (FERREIRA, 2011).

3. RESULTS AND DISCUSSION

The seeds of *C. argentea* and *C. cristata* presented mass of one thousand seeds of 0.76 and 0.90 g and 11.51% and 11.62% of humidity, respectively.

In Table 1, we observed that the vigor of seeds (first count of germination) performed on 4th day after sowing (DAS) for the temperature of 15 ºC does not present germination in the two lighting regimes and for the two species of cockscombs. In this temperature, there was a delay in germination starting on the 10th DAS. Okusanya (1980) studying the germination of *C. cristata* in different intensities of light and temperature, verified inhibition of germination in the temperature range from 15 to 21 ºC. Menezes et al. (2004), also, observed minor germinative percentage for the seeds of *Salvia splendens* Sellow at the temperature of 15 ºC in presence of light.

In relation to the germination of normal seedlings carried out on the 14th DAS, we verified that for the two lighting regimes, germinative percentage was above 70% for the temperatures of 20, 25 and 30 ºC, demonstrating elevated physiological potential of these seeds (Table 1). The germination of seeds only occurs between determined limits of temperature and it will be faster and more efficient, if it remains more time next to the great value for the species (CASTRO and VIEIRA, 2001).

TTemperatures that are not inside the great range of germination, for the cockscomb from 20 to 30 ºC, independent of the lighting regime, cause reduction of germination rate in result of the low metabolic activity started by the process of soaking and, consequently, restrict the velocity of germination and the number of seeds germinated in the end of the test (CARVALHO and NAKAGAWA, 2000; LARCHER, 2000).

We observed, in this study, that the germination of the two species of cockscomb are indifferent to presence of light, characterizing them as neutral photoblastic, according to what was proposed by Labouriau (1983), that is, they germinate with the presence and absence of light. Ferreira et al. (2012) working with different methods for the overcoming of seeds dormancy of *C. cristata* verified great germinative percentages for the all the methods with presence of light. Yet Okusanya (1980) verified that the germination of seeds of *C. cristata* occurs independent of different intensities or even absence of light.

Scalon et al. (2009) working with *Pfaffia glomerata* (Spreng) Pedersen, species of the Amaranthaceae family, observed that the same is neutral photoblastic with germination in the presence and absence of light. Santos et al. (2016) verified that the seeds of *Costus arabicus* L. germinated in presence or absence of light, characterizing as neutral photoblastic, and the germination with light at 30 ºC was more efficient.

The value of IVG (index of velocity of germination) was increasing according to the temperature rise of seeds exposure, for the two species of cockscombs in both lighting regime (Table 1). Muniz et al. (2001) reported that the IVG is a parameter that evaluates the effect of different environmental conditions in which the seeds are submitted. Sousa et al. (2008) observed a decline in IVG of seeds of *Plantago ovata* Forsk submitted to temperatures of 5, 10 and 15 ºC in relation to the temperatures of 20 to 35 ºC, similar performance observed in this study.

We observed similarity of entropy for the two species of cockscomb, measuring the synchronization of germination independent of the lighting regime adopted, inside the same temperature range (Table 1). This similarity for both species corroborates with the study of Carvalho and Carvalho (2009) with *Sida rhombifolia* L. under the effect of lighting, in which the entropy was not influenced by the presence or absence of light in the test of germination.

The synchronization of entropy verified for the species *C. argentea* indicates better organization of the germinative system in the temperature range from 20 to 35 ºC in presence of light and, for *C. cristata* this similarity in synchronization occurs between 20 and 25 ºC for both lighting regimes. Nassif and Perez (2000) mentioned that the organization and the synchronization of the germinative system have direct association with the adaptability of the species to the different environmental conditions in which they are submitted. Vieira et al. (2007) observed low values of entropy for the germination of seeds of *Dyckia tuberosa* (Vell.) Beer in temperature of 15 ºC, in relation to the temperature great range around 30 to 35 ºC, indicating lower synchronization of the germinative system.

The variables of mean time of germination (TMG) and daily mean velocity of germination (VMD), for the two species of cockscomb, have a relation inversely proportional, that is, the briefer TMG is, the faster is VMD (Table 1). This relation demonstrates how accelerated is the mobilization of the reverses of seeds in generate a seedling. Marcos Filho (2015) exemplifies that the initial development of seedlings is expressed by the germination rate that can be related with the adaptability and the interaction of seeds with the climate conditions to which they were exposed.

We observed that the VMD for the two species of cockscomb at temperature of 15 ºC were lower in relation to the other temperatures tested in this study, they needed more numbers of days to germinate. The submission of seeds to different temperatures can cause acceleration in the deterioration, once that, all these physiological alterations are related directly to the hydrolysis of the reserves, with the degradation of amide and synthesis of sugar in endosperm, or to biosynthesis of new tissue, essential processes for the germination under favorable environmental conditions (DEVI et al., 2007; CARVALHO et al., 2009; TAIZ and ZEIGER, 2009).

The similarity of the germinative percentage and of VMD in the temperature range from 20 to 30 ºC for the two lighting regimes adopted in this study, for both species of cockscomb, is indicative of neutral photoblastic. Similar results were observed by Silva et al. (2016) for the seeds of *Jatropha curcas* L., in which the lighting regime does not interfere in germination of seeds of this species.

Table 1. First germination count (vigor), germination of normal seedlings (GER), germination velocity index (IVG), entropy (bits) and mean germination time (TMG) and mean germination speed (VMD) of seeds *Celosia argentea* L. and *Celosia cristata* L. in function of different temperatures and light regime.

Temperatures (ºC)	*C. argentea*		*C. cristata*	
	Absence of light	Presence of light	Absence of light	Presence of light
	VIGOR (%)		VIGOR (%)	
15	0 Ad*	0 Ad	0 Ac	0 Ad
20	81 Aa	80 Ab	61 Bb	88 Aa
25	76 Bb	82 Aa	85 Ba	89 Aa
30	77 Bb	84 Aa	64 Bb	69 Ab
35	67 Ac	69 Ac	60 Ab	39 Bc
CV (%)	9.50		12.91	
	GER (%)		GER (%)	
15	48 Bd*	65 Ac	37 Bd	42 Ad
20	81 Aa	83 Aa	80 Bab	88 Aa
25	81 Aa	82 Aab	85 Ba	89 Aa
30	77 Bb	85 Aa	79 Ab	74 Bb
35	67 Ac	69 Ac	62 Ac	61 Ac
CV (%)	11.65		9.06	
	IVG		IVG	
15	4.439 Ae	2.455 Be	2.482 Ad	2.673 Ae
20	26.583 Bd	45.858 Ad	41.463 Ac	42.579 A
25	70.425 Ac	66.458 Bc	73.988 Ab	66.017 Bb
30	79.404 Bb	86.804 Ab	84.938 Aa	75.271 Bb
35	83.908 Ba	92.063 Aa	85.258 Aa	81.404 Ba
CV (%)	11.55		6.84	
	ENTROPY (bits)		ENTROPY (bits)	
15	1.305 Ab	1.028 Ab	0.730 Ac	0.799 Ad
20	1.876 Bb	2.658 Aa	2.352 Ab	2.573 Aa
25	2.081 Ba	2.586 Aa	2.973 Aa	2.719 Aa
30	2.859 Aa	2.456 Aab	3.158 Aa	2.469 Bb
35	2.866 Aa	2.516 Aa	2.248 Ab	1.229 Bc
CV (%)	13.19		6.42	
	TMG (days)		TMG (days)	
15	10.5 Aa	11.0 Aa	11.5 Aa	10.5 Ba
20	4.6 Ab	3.1 Bb	5.2 Ab	3.2 Ab
25	4.5 Ab	2.8 Ab	4.7 Abc	2.9 Abc
30	4.6 Ab	2.6 Bb	4.6 Ac	2.6 Ac
35	4.6 Ab	2.5 Bb	4.6 Ac	2.6 Bc
CV (%)	4.01		3.82	
	VMD ($days^{-1}$)		VMD ($days^{-1}$)	
15	0.095 Ab	0.091 Ac	0.087 Bc	0.095 Ac
20	0.217 Ba	0.323 Ab	0.192 Bb	0.313 Ab
25	0.222 Ba	0.357Aab	0.213 Ba	0.345 Aa
30	0.217 Ba	0.385 Aa	0.217 Ba	0.385 Aa
35	0.217 Ba	0.400 Aa	0.217 Ba	0.385 Aa
CV (%)	9,45		9,68	

* Averages followed by the same capital letter in the row and lowercase in the column, do not differ at the level of 5% error by the Tukey test. CV: coefficient of variation.

In Figure 1, the relative frequency of germination of seeds was distributed in similar form for the two species of cockscomb. Nevertheless, we observed that the germination in the presence of light was anticipated in relation to the treatments with absence of light for the tested temperatures, which resulted in variation of TMG among the lighting regimes.

The distributions of frequencies for the temperatures of 20, 25, 30 and 35 ºC followed a modal, which demonstrates homogeneity of physiological potential of the seeds in function of the difference of temperature, observing that the beginning of germination of seeds of *C. argentea* and *C. cristata* occurred with TMG from 2.5 and 4.5 days for the regimes with presence of light and absence of light respectively.

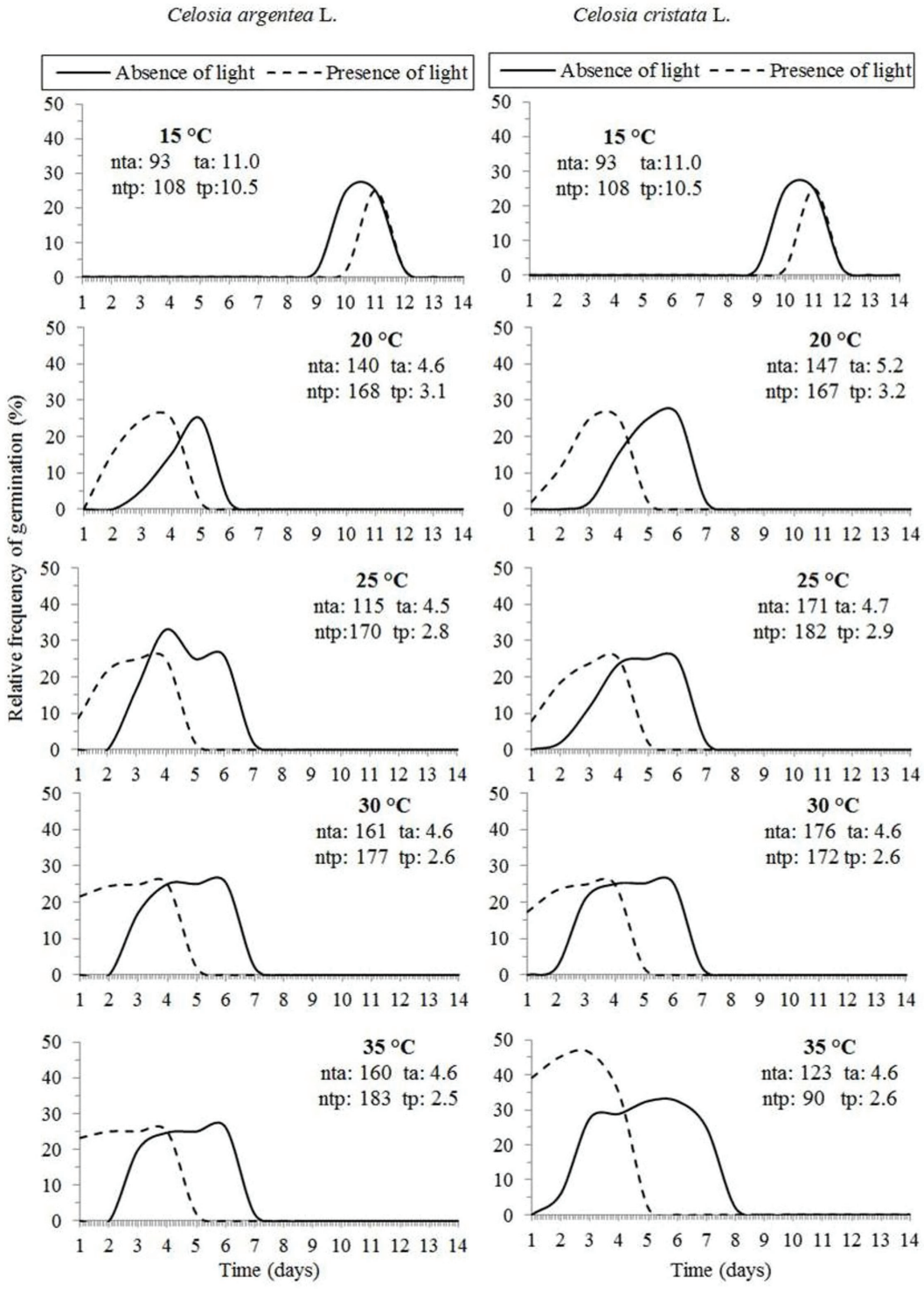

Figure 1. Relative frequencies (%) of the germination of *Celosia argentea* L. and *Celosia cristata* L. seeds as a function of different temperatures and light regime. nt: total germinated seeds. t: mean germination time (in days). a: absence of light and p: presence of light.

We verified that the germinative process of the two species of cockscomb at the temperature of 15 ºC was slower in relation to the other temperatures tested for the two lighting regimes, with TMG from 10 days. Alves et al. (2011) attributed the displacement of the relative frequency line in function of the average time, to a delay in the germinative process of seeds of *Peltophorum dubium* (Spreng.) Taubert provoked by a limiting factor. In this study the limiting factor is the temperature of germination at 15 ºC.

Lopes and Franke (2011) reported that the similarity of distributions of frequencies demonstrate quality of genetic material and adaptability to the different environmental conditions. Vieira et al. (2007) observed that the germination of seeds of *Dyckia tuberosa* (Vell.) Beer are indifferent to the lighting presenting high germinative rate, however, the authors verified that the low temperature (10-15 ºC) is a limiting factor to the germination of this species, presenting unimodal relative frequency, corroborating with this study.

4. CONCLUSIONS

The two species of cockscomb (*Celosia argentea* L. and *Celosia cristata* L.) presented germination in presence and absence of light, characterizing themselves as neutral photoblastic. The temperature is a limiting factor for the germination of the two species of cockscomb, and its great temperature range is between 20 to 30 ºC.

AUTHORS CONTRIBUTIONS

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.

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