



Germination and vigor of *Caesalpinia pulcherrima* (L.) Sw. seeds under different light and temperature conditions

Magnólia Martins Alves^{1*}  Edna Ursulino Alves² Luciana Rodrigues de Araújo²
 Maria de Lourdes dos Santos Lima² Marina Matias Ursulino²

¹Programa de Pós-graduação em Agronomia, Centro de Ciências Agrárias (CCA), Universidade Federal da Paraíba (UFPB), 58397-000, Areia, PB, Brasil. E-mail: magecologia@hotmail.com. *Corresponding author.

²Departamento de Fitotecnia e Ciências Ambientais, Centro de Ciências Agrárias, Universidade Federal da Paraíba (UFPB), Areia, PB, Brasil.

ABSTRACT: *Caesalpinia pulcherrima* is a Fabaceae family species from Central America, which has a small size and is widely used as a living fence in the urban afforestation for streets, parks, and gardens. Based on this importance, the aim of this research was to study the influence of light and temperature on the germination of *C. pulcherrima* seeds. The study was carried out at the Laboratory of Seed Analysis of the Center of Agricultural Sciences of the Universidade Federal da Paraíba, Areia, PB, Brazil. The experimental design was completely randomized, comprising a 3x5 (three temperatures and five light regimes) factorial scheme with four replicates containing 25 seeds each. Germination and vigor of seeds were evaluated under temperatures of 25°C and 30°C constant and 20-30°C alternated in different light regimes: white, green, red-distant, red, and absence of light. Variables analyzed were: germination, first germination count, germination speed index, root length, shoot length, and the ratio of dry mass of root/shoot of the seedlings. Seeds of *C. pulcherrima* germinate in the presence and absence of light, being a neutral photoblastic. Recommendation to test the vigor of these seeds is the temperature of 30°C in the white light regime.

Key words: flamboyant mirim, photoblastism, vigor.

Germinação e vigor de sementes de *Caesalpinia pulcherrima* (L.) Sw. Sob diferentes condições de luz e temperatura

RESUMO: *Caesalpinia pulcherrima*, pertence à família Fabaceae, é uma espécie exótica originada da América Central, apresenta pequeno porte, muito utilizada como cerca-viva em arborização de ruas, parques e jardins. Diante de sua importância o trabalho teve como objetivo estudar a influência da luz e temperatura na germinação de sementes de *C. pulcherrima*. A pesquisa foi conduzida no Laboratório de Análise de Sementes, do Centro de Ciências Agrárias da Universidade Federal da Paraíba, em Areia, PB, Brasil. O experimento foi conduzido em um esquema fatorial 3x5 (três temperaturas e cinco regimes de luz) com quatro repetições, contendo 25 sementes para cada tratamento. Avaliou-se a germinação e vigor das sementes sob temperaturas de 25°C e 30°C constantes e 20-30°C alternada em diferentes regimes de luz: branca, verde, vermelha-distante, vermelha, e ausência de luz. As variáveis analisadas foram: germinação, primeira contagem de germinação, índice de velocidade de germinação, comprimento de raiz/parte aérea e massa seca de raiz/parte área de plântulas. As sementes de *C. pulcherrima* germinam na presença e ausência de luz, sendo um fotoblástico neutro. A recomendação para testar o vigor dessas sementes é a temperatura de 30°C no regime de luz branca.

Palavras-chave: flamboyant mirim, fotoblastismo, vigor.

INTRODUCTION

Caesalpinia pulcherrima (L.) Sw. belongs to the Fabaceae family and is an exotic species originated from the Central America. It is commonly known as dwarf poinciana, “baio-de-estudante”, “Flamboyanzinho”, and flamboyant- “mirim”. Fruits and seeds are produced abundantly throughout the year, being the seed the main way of propagation (LORENZI, 2009).

The species has been studied because of its easy growth and capability of producing large quantity of seeds (BRAGA et al., 2011). Seeds are considered an important guarantee of the survival for plants species.

Being mainly composed by embryo, endosperm, and tegument, and these organs are strongly influenced by environmental differences, such as temperature, light, and humidity (ABUD et al., 2010).

Temperature directly interferes with the physiological quality of the seeds and can act on the speed of water absorption and in the biochemical processes, thus affecting the percentage, speed, and uniformity of their germination (CARVALHO & NAKAGAWA, 2012). According to the same authors, temperature and light are considered important environmental factors for the germination, because the temperature affects both the final percentage, as well as the speed of germination.

For the germination of different species, it is recommended the use of a specific temperature and a type of ideal substrate, besides the light that may be required during this process (RIBEIRO et al., 2012). However, even though light is not considered an essential factor for the germination process, in non-dormant seeds, its presence may contribute to mitigate problems caused by low soil water potential and the effects of temperatures higher than optimal (MARCOS FILHO, 2005).

The action of this pigment depends on the type of incident radiation, since light with a high red/red-extreme ratio (V/LV) can induce it to take the active form (FVE), promoting the germination of photosensitive seeds (VÁZQUEZ-YANES & OROZCO- SEGOVIA, 1990).

Knowledge of how environmental factors influence seed germination is extremely important. Thus, they can be controlled and manipulated in order to optimize the percentage, speed and uniformity of germination, resulting in the production of more vigorous seedlings for planting.

The knowledge of the requirements of germination is regulated by the interaction of its ecophysiological state and the environmental conditions. Then, the objective of this research was to evaluate the influence of light and temperatures on the germination and vigor of *Caesalpinia pulcherrima* L. seeds.

MATERIALS AND METHODS

Place of experiment

The experiment was conducted at the Laboratory of Seed Analysis, belonging to the Department of Phytotechny and Environmental Sciences of the Center of Agricultural Sciences, Universidade Federal da Paraíba, state of Paraíba.

Fruits were collected from mother-plants in the municipality of Areia, state of Paraíba. Afterwards, they were transported to the Laboratory of Seed Analysis for processing, where they were manually opened to get seeds, and subsequently submitted to determinations and tests as described below.

Water content

Water content of seeds was obtained by the standard method of the drying oven at $105\pm 3^{\circ}\text{C}$, according to the rules of the Brazilian Rules for Seed Analysis (BRASIL, 2009), with four samples of 10 seeds each, being results expressed as a percentage.

Temperatures and luminosity

For each treatment, 100 seeds were used, being divided into four replicates of 25 each. The

test was carried out in seed germination chambers adjusted to the constant temperatures of 25 and 30°C , and also alternated of $20\text{-}30^{\circ}\text{C}$. Light regimes were white, green, red, far-red, and absence of light. In order to simulate the obtaining of light waves, cellophane paper was combined, and for the white light treatment, the germination tests were carried out under the normal laboratory lighting. For green light, seed rolls were wrapped with two sheets of green cellophane paper; to obtain the red light, two sheets of red cellophane paper were used, while for the far-red, the covering was made with three sheets of overlapped cellophane papers (red-blue-red), and the absence of light was obtained using black plastic bags. The regimes were 8 hours with light (daytime) and 16 hours without light (night time) and for the dark condition (total absence of white light).

Germination test

The forest species usually present the mechanism of dormancy, so it was performed a treatment to overcome this dormancy, by scarification with manual sanding using sandpaper N° 80 in the region opposite to the thread followed by the methodology of Oliveira et al. (2010).

For the germination test, 100 seeds were used, being divided in four replicates of 25 each, and distributed on two sheets of paper towel, covered with a third and organized in roll shape. The paper towel was moistened with distilled water in the amount equivalent to 2.5 times the mass of dry paper (BRASIL, 2009). The germination tests ending 14 days were performed in B.O.D germination chambers with controlled temperature and light.

For the counting of germinated seeds

For beginning at 6 days after sowing, it was considered as normal seedlings those that had emitted the primary root with the emission of the cotyledons.

Index of germination speed (IVG)

The index was calculated using the formula proposed by Maguire (1962). The criterion used in the evaluations was the normal seedlings with perfect essential structures (BRASIL, 2009).

Root and shoot length of seedlings

After the final germination test counts at 14 days after sowing, the normal seedlings of each treatment and the repetition had measured the root and shoot using a ruler graduated in centimeters, and results were expressed in cm/seedling^{-1} .

Dry mass of root and shoot of seedlings

The same seedlings of the previous evaluation were placed in Kraft paper bags and taken to the oven set at 65°C until reaching constant weight (48 hours). After that period, the samples were weighed in an analytical balance with an accuracy of 0.001g, being the results expressed in g/seedling⁻¹.

Experimental design and statistical analysis

The experimental design was completely randomized, with treatments distributed in a 5x3 factorial scheme (light regimes and temperatures), using four replicates of 25 seeds each. According to the tests of normality and homogeneity of variances there was no need for data transformations. The data were submitted to analysis of variance and the means were compared by the Scott-Knott test up to 5% of error probability, using the statistical program *Sisvar*[®] (FERREIRA, 2000).

RESULTS AND DISCUSSION

The water content of the seeds of *C. pulcherrima* at the time of performing the experiment was 10%. By the analysis of variance it was verified interaction between conditions of light and temperature for all the analyzed variables demonstrating that these are dependent.

Considering the factors alone, there was a significant difference at the 1% probability level for germination, first count, germination speed index, length area, root dry mass and except for shoot, with no significant difference for root length.

Seeds of *C. pulcherrima* germinated satisfactorily at the three tested temperatures (25, 30 and 20-30°C). Regarding the effects of light at each temperature, it was observed that at 25°C the highest germination percentages occurred under the light regimes of green, red, far-red, and dark; at 30°C, it was under white, green, red, and dark lights; at 20-30°C, the highest percentages of germination were under white, red, and far-red lights (Table 1).

However, the germination was not restricted just to light, since it also occurred in the dark, and can be a neutral photoblastic, showing that the seeds of *C. pulcherrima* can germinate not only in clearings, but also under the canopy of different strata.

For many species the presence of light favors the germination of the seeds, which in this case was not favorable to *C. pulcherrima* for germination, being able to consider at the first moment, that it could be considered negative photoblastic.

Therefore, when evaluating results, it was observed that at temperatures of 30°C and 20-30°C

Table 1 - Germination (%) of *Caesalpinia pulcherrima* under different light regimes and temperatures.

Light cycles	-----Temperatures (°C)-----		
	25	30	20-30
White	88bB	98aA	96aA
Green	95aA	94aA	84bB
Red	95aA	94aA	97aA
Far red	93aA	85bB	97aA
Dark	95aA	99aA	86bB

Means followed by the same letter, lowercase in the column and upper case in the row, do not differ statistically from each other, a 5% probability by the Scott-Knott test.

there was interference of white light on germination, allowing to infer that *C. pulcherrima* is indifferent to photoblastic however, because it receives a quantity of light in the moment of evaluation, it can be affirmed that the species studied is considered neutral photoblastic.

According to Barroso et al. (2010) studying *Sinningia leucotricha*, the luminosity and substrates promoted superior results when the seeds were in the presence of light. In seeds of *Clitoria fairchildiana* Howard, only in the dark condition at 25°C, the germination was significantly lower considering light (ALVES et al., 2012). For the species *Dalbergia cearenses* Ducke, seeds submitted to treatments with a constant temperature of 45°C and alternated temperature of 20-45°C with 12 hours of light/12 of dark did not present a satisfactory germination (NOGUEIRA et al., 2014). Seeds of *Murdannia nudiflora* promoted greater germination when submitted to light and at temperatures of 25 and 30°C (LUZ et al., 2014). There was an interaction between the temperature and luminosity for the germination of *Sinningia leucotricha* (Hoehne) Moore (MORITZ et al., 2015).

Table 2 shows the results for the vigor of seeds evaluated by the first germination count, in which

Table 2 - First seed germination count *Caesalpinia pulcherrima* under different light regimes and temperatures.

Light cycles	-----Temperatures (°C)-----		
	25	30	20-30
White	43aC	7aA	54bB
Green	33bC	4cB	64aA
Red	33bC	64bA	55bB
Far red	21dB	63bA	63aA
Dark	29cA	25dA	25cA

Means followed by the same letter, lowercase in the column and upper case in the row, do not differ statistically from each other, a 5% probability by the Scott-Knott test.

is presented the obtained significant interaction between light regimes and temperatures. The highest percentage of germination was verified at 30°C, when seeds were sown under the white light regime; however, the temperature of 25°C was harmful to seedlings formation.

Another relevant parameter to highlight is the influence of the temperature exerted on the germination of this species. In the treatments in which the temperature of 25°C was used, there was a significant decrease in the percentage of germination in relation to the treatments in which the temperature of 30°C was proposed.

According to Bergo et al. (2010), the ability of seeds to germinate under different environmental conditions may have useful consequences, since for some seeds, germination will occur regardless of the conditions of their environment.

The highest percentage of germination in seeds of *Clitoria fairchildiana* Howard occurred at 25°C in the green, red, and dark light regimes; at 30°C in white light; and at 20-30°C in the green and far-red lights (ALVES et al., 2012). Variations in the temperatures required by the plants species are an adaptive characteristic that gives them a high capacity to establish themselves in the field, since it allows the seeds to germinate in a greater range of temperatures (PACHECO JUNIOR et al., 2013). For the species *Buchenavia tomentosa*, Azevedo et al. (2015) verified a higher percentage of germination when submitted to 25°C.

Knowledge about the ecophysiology of plant species and establishment of seedlings in the field will allow us to better understand how these plant species can develop and survive in this type of seasonal environment (NOGUEIRA et al., 2014).

The data for the germination rate index of *C. pulcherrima* seeds are shown in table 3. There was a higher germination index when seeds were placed at the temperature associated to the green, red and dark

light regimes at the temperature of 30°C favoring the germination index when the seeds in the presence of light however, at the temperature of 20-30°C the highest IVG was achieved in red and red-distant light regimes.

However, there are more adequate conditions for germination for each species, and the physiological characteristics of these species are different, especially regarding the presence or absence of light on the germination (MONDO et al., 2010). In seeds of *Crataeva tapia* L., it was observed that at 20-30°C, the highest indexes of germination speed occurred when white, green, and red light regimes were used (GALINDO et al., 2012). Thus, the germination of seeds in response to light is an ecophysiological response of the species, which is correlated with its positioning in the successional stage of the forest (CARVALHO & NAKAWAVA, 2012).

In order to obtain the maximum seed germination potential of a species, it is necessary to know the necessity of the factors of luminosity and temperature during this process. The root length of *C. pulcherrima* seedlings had no significant interaction between light regimes and temperatures. Temperature of 30°C provided higher root length and the light regimes proved to be more efficient in the white and far-red lights table 4. Alternating temperature of 20-30°C provided greater length of the root of *Clitoria fairchildiana* in the regime of distant red light (ALVES et al., 2012). The largest root length of the *Platymiscium floribundum* Vog seedlings were reported at the constant temperature of 25°C in the distant white and red light regimes, while at the 30°C temperature, the primary root lengths were obtained in the distant red light regimes and in the absence of continuous light (ALVES, et al. 2016).

Shoot length of the seedlings of *C. pulcherrima* at constant temperatures of 25°C and alternated at 20-30°C, regardless of the light regime employed, was not favorable for the development of the seedlings. At 30°C, the green, red, far-red, and dark light regimes provided the highest shoot lengths of the *C. pulcherrima* (Table 5).

Table 3 - Index seed germination speed *Caesalpinia pulcherrima* under different light and temperature regimes.

Light cycles	-----Temperatures (°C)-----		
	25	30	20-30
White	2.55bA	3.02aA	2.68bA
Green	2.54aA	2.64aB	2.49aB
Red	2.52aA	2.79aB	2.76aA
Far red	2.42bA	2.68aB	2.76aA
Dark	2.31aA	2.60aB	2.31bB

Means followed by the same letter, lowercase in the column and upper case in the row, do not differ statistically from each other, a 5% probability by the Scott-Knott test.

Table 4 - Root length of *Caesalpinia pulcherrima* seedlings submitted to different light and temperature regimes.

Temperatures	Means	Light cycles	Means
25°C	7.61b	White	7.93a
30°C	8.49a	Green	7.36b
20-30°C	7.66b	Red	7.63b
		Far red	8.37a
		Dark	8.30b

Averages followed by the same letter in the column are statistically equal to each other by the Tukey test at 5% significance.

Table 5 - Length shoot of *Caesalpinia pulcherrima* seedlings from seeds under different light and temperature regimes.

Light cycles	-----Temperatures (°C)-----		
	25	30	20-30
White	7.88bB	10.22bA	7.52cB
Green	9.04aC	10.93aA	9.87aB
Red	8.02bB	11.27aA	8.67bB
Far red	9.40aB	10.85aA	8.70bC
Dark	9.64aB	11.35aA	10.21aB

Means followed by the same letter, lowercase in the column and upper case in the row, do not differ statistically from each other, a 5% probability by the Scott-Knott test.

Thus, there is a difference in temperature requirement for the development of different parts of the seedling. Silva et al. (2014) reported for seeds of 'quixaba' [*Sideroxylon obtusifolium* (Roem. & Schult.)] that the highest length of the shoot was when the seeds were at 25°C in the regime of white and far-red lights; at 30°C, it was in red and far-red lights; and at 20-30°C, it was in red, far-red, and dark light regimes.

The highest dry mass of roots of *C. pulcherrima* seedlings was found when seedlings were submitted to the temperature of 20-30°C in the green, red, and far-red light regimes. Thus, there must have been a greater allocation of reserves from the storage tissues and a greater incorporation of them by the embryonic axis. Similar behavior was observed at 25°C under a regime of white and red lights, and at 30°C when associated with red light, resulting in seedlings with higher dry mass (Table 6).

Table 6 - Dry mass of roots of *Caesalpinia pulcherrima* seedlings from seeds under different light regimes and temperatures.

Light cycles	-----Temperatures (°C)-----		
	25	30	20-30
White	0.0062aA	0.0055bB	0.005bB
Green	0.0055bB	0.0062aB	0.0067aA
Red	0.0067aA	0.0075aA	0.0072aA
Far red	0.0065bA	0.0060bB	0.0075aA
Dark	0.0055bB	0.0057bB	0.0055aA

Means followed by the same letter, lowercase in the column and upper case in the row, do not differ statistically from each other, a 5% probability by the Scott-Knott test.

Root length of *Parkia pendula* Willd seedlings at 25 and 30°C was higher compared to the others temperatures (ROSSETO et al., 2009). The length of the primary root of *Clitoria fairchildiana* (R.A. Howard) seedlings at 25°C in the green, red, and far-red light regimes was higher (ALVES et al., 2012).

Seedlings of *Simira gardneriana* M.R. ("pereiro-vermelho") showed lower accumulation of dry mass when the seeds were submitted to a constant temperature of 35°C (OLIVEIRA et al., 2016). The highest dry mass contents of the roots of *Platymiscium floribundum* Vog were reported in seedlings from seeds submitted to temperatures of 25°C in the regimes light of green, white, red distant, red and dark (ALVES, et. al., 2016).

Analyzing the data of the shoot dry mass (Table 7), it is observed that at the temperature of 25°C the highest dry mass content was reported in the green light regime, in turn, at 30°C, it was noticed greater dry mass content under green and red light, whereas at 20-30°C, it was the light regime of dark. Taking the light regimes, it is noticed that the red light at 25°C provided the lowest dry mass content of shoot. Initial development of *Crataeva tapia* L. seedlings evaluated by shoot length at 35°C, regardless of the applied light regime, was not adequate (GALINDO et al., 2012). The highest dry mass content of the shoot of *Clitoria fairchildiana* (R. A. Howard) seedlings occurred at 25°C in the white, green, and dark light regimes. At 30°C, in the green, far-red and dark light regimes, while at the alternated temperature of 20-30°C, it was in the red-light regime (ALVES et al., 2012).

Table 7 - Mass shoot dry of *Caesalpinia pulcherrima* seedlings from seeds under different light regimes and temperatures.

Light cycles	-----Temperatures (°C)-----		
	25	30	20-30
White	0.0317bA	0.0335bA	0.0322bA
Green	0.0350aA	0.0357aA	0.0322bB
Red	0.0305bC	0.0362aA	0.0335bB
Far red	0.0317bB	0.0342bA	0.0320bB
Dark	0.0340aB	0.0330bB	0.0362aA

Means followed by the same letter, lowercase in the column and upper case in the row, do not differ statistically from each other, a 5% probability by the Scott-Knott test.

CONCLUSION

Seeds of *C. pulcherrima* germinate in the presence and absence of light, being considered as neutral photoblastic. Interaction between temperature and light showed that at constant temperatures of 25 and 30°C, white light and distant red reduce the germination percentage respectively, while at the alternating temperature of 20-30°C the green light caused this reduction.

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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