

Effects of Temperature, Light and Seed Moisture Content on Germination of *Euterpe precatoria* Palm

Carla Rafaela Xavier Costa¹, Kathia Fernandes Lopes Pivetta¹,
Gilberto Rostrolla Batista de Souza¹, Renata Bachin Mazzini-Guedes²,
Suzana Targanski Sajovic Pereira¹, Marina Romano Nogueira¹

¹São Paulo State University—UNESP, Jaboticabal, Brazil

²Federal University of Paraná (UFPR), Jandaia do Sul, Brazil

Email: remazzini@yahoo.com.br

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Abstract

The aim of this study was to investigate the effects of different temperatures, light regimes, and seed moisture contents on germination of the palm *Euterpe precatoria*, in the Arecaceae family. For the study of light and temperature, the experimental design was entirely randomized; treatments were arranged in a 6 × 2 factorial scheme [six temperature conditions (20°C, 25°C, 30°C, 35°C, 20°C - 30°C, and 25°C - 35°C) combined with two light regimes (light and darkness)] with four replications composed of 25 seeds each. For the seed moisture content study, the experimental design was entirely randomized with five seed moisture contents (27%, 20%, 13%, 12%, and 11%), to which they comprised 5 treatments, and four replications with 25 seeds each. Number of germinated seeds was recorded daily until germination was steady. Data were submitted to variance analysis; for the first experiment, means were compared by the Tukey test ($p \leq 0.05$) and, for the second, the regression analysis was performed. The temperature at 20°C promoted highest germination percentage and germination rate for *E. precatoria* seeds, under either light or darkness; seeds were tolerant up to 11% moisture content.

Keywords

Areaceae, Luminosity, Ornamental Palm, Seed Desiccation

1. Introduction

Euterpe precatoria Mart., in the family Arecaceae, is a single-stemmed palm occurring naturally in the Amazon region of Acre, Amazonas, Pará, and Rondônia

states, Brazil, measuring from 3 to 20 m height [1]. Commonly known as Amazonian açai or mountain cabbage, it shows great economic potential mainly because of its fruits. A thick liquid, called “açai wine”, is extracted from the fresh edible mesocarp, which is the most used part. Such beverage is largely consumed by the entire population from the Brazilian Amazon [2]. Furthermore, the açai juice of *E. precatoria* presents potential as a source of energy, lipids, dietary fiber, anthocyanins, monounsaturated fatty acids, and minerals [3]. The palm is also used for the extraction of heart of palm and timber.

In general, palm seed germination is slow and uneven, usually resulting in low seedling stand. Its propagation is made almost exclusively from seeds with a great variation on the germination process that, also, is influenced by several factors [4] [5], such as temperature, light, and moisture.

The temperature at germination influences, for instance, the speed of water absorption by seeds and may change, among others, the total germination percentage, rate, and uniformity [6]. For germination of palm seeds, temperatures considered appropriate vary from 20°C to 40°C, but best results are obtained from 30°C to 35°C for most species [5]. Furthermore, seeds of many species germinate better when submitted to the range of 25°C to 35°C [4].

For some ecological groups, light presence may affect seed germination [6]. However, seed sensitivity to light is highly variable and specific, so seeds may be either positively or negatively influenced and, yet, indifferent [7].

Many plant species produce seeds that lose viability according to dehydration [8], so tolerance to low seed moisture contents also varies among species [9].

Our objective was to verify the effects of different temperatures, light regimes, and seed moisture contents on germination of the palm *Euterpe precatoria*.

2. Materials and Methods

Two experiments were conducted to study: 1) the effects of temperature and light on seed germination of *E. precatoria*; and 2) the effects of seed moisture contents on germination of *E. precatoria*. Both were implemented in the Laboratory of Seed Analysis belonging to the Department of Crop Production at the College of Agricultural and Veterinary Sciences of the São Paulo State University—UNESP, located in the municipality of Jaboticabal, Brazil (21°15'22"S and 48°18'58"W, at 590 m altitude).

Fruits were harvested from native palms naturally growing in the municipality of Humaitá, Amazonas State, Brazil (07°30'22"S and 63°01'38"W, at 59 m altitude). According to the Köppen classification, the climate regime in Humaitá is of Am type—tropical monsoon, or tropical wet climate, with wet and dry seasons and steady temperatures along the year. After harvest, fruits were packed in plastic bags with vermiculite of medium texture and transported to Jaboticabal.

In the lab, fruits were kept in water for 24 hours to ease pulp removal and then epicarp and mesocarp were removed by manual friction against a steel mesh sieve. Seed initial moisture content (botanically, a pyrene) was determined

gravimetrically by oven drying for 24 hours at $105^{\circ}\text{C} \pm 3^{\circ}\text{C}$ [10], using two samples of 10 seeds each.

For the study of temperature and light effects, the experimental design was entirely randomized. Treatments were arranged in a 6×2 factorial scheme [six temperature conditions (constant at 20°C , 25°C , 30°C , and 35°C , and alternated at $20^{\circ}\text{C} - 30^{\circ}\text{C}$ and $25^{\circ}\text{C} - 35^{\circ}\text{C}$) combined with two light regimes (light and darkness)] with four replications of 25 seeds each.

Seeds were placed in transparent plastic boxes ($11 \times 11 \times 3$ cm) for the light treatment, or in black ones for the darkness treatment, which were filled with vermiculite of medium texture kept at 100% of its water retention capacity, previously studied by the gravimetric method. The plastic boxes were then packed in transparent plastic bags. The photoperiod, for the light treatment, was of 16 h light in a germination chamber.

For the study of seed moisture contents, the experimental design was entirely randomized, with five treatments composed of different seed moisture contents (27%, 20%, 13%, 12%, and 11%) and four replications of 25 seeds each.

Treatments were established according to the seed moisture content [10]. Thus, the first treatment was the initial seed moisture content (27%), while the others were determined every three days after diaspore drying at room temperature; therefore, the last treatment was obtained after 12 days of drying.

Seeds were placed in transparent plastic boxes ($11 \times 11 \times 3$ cm) filled with vermiculite of medium texture kept at 100% of its water retention capacity, previously studied by the gravimetric method. The plastic boxes were then placed in a germination chamber at 30°C .

Seeds of both experiments were considered germinated when seedlings first appeared. Numbers of germinated seeds were noted daily, always at the same time, until germination was steady.

Data were submitted to the variance analysis. For the temperature and light experiment, means were compared by the Tukey test ($p \leq 0.05$); for the seed moisture content experiment, the polynomial regression was performed to verify variable behavior (germination percentage and germination rate) due to decreasing moisture content, defining the best adjustment according to the combination of significance and highest determination coefficient. Data of germination rate was calculated as

$$\text{GR} = N1/D1 + N2/D2 + \dots + Nn/Dn,$$

where GR is the germination rate, N is the number of normal seedlings noted from the first to the last counting, and D is the number of days from the first to the last counting [11]. Data of germination percentage were transformed into arcsine $(x/100)^{1/2}$ for normalization.

3. Results

There was an interaction among temperatures and light regimes for both germination percentage and germination rate; when seeds were submitted to light,

there was no difference among temperatures, with the exception of the constant temperature at 35°C, which promoted the lowest values. Under darkness, higher germination percentages were obtained under the constant temperatures at 20 and 25°C, and the alternated at 20°C - 30°C (**Table 1**).

Regarding the germination rate, seeds germinated faster when submitted to light, at 20°C; in turn, the latter did not differ from the constant temperature at 25°C, and alternated at 20°C - 30°C and 25°C - 35°C. Under darkness, 20°C was also the temperature that promoted the highest means (**Table 1**).

The temperature at 20°C promoted highest means of both germination percentage and germination rate, under light or darkness; on the other hand, the 35°C treatment resulted in the lowest means regardless light presence (**Table 1**).

Regarding seed tolerance to low moisture contents, both germination percentage and germination rate decreased according to reduced seed moisture content (**Figure 1**). Therefore, high germination percentage was obtained immediately after harvest. However, even with decreasing germination according to moisture loss, germination was high, of about 95%, 89%, 84%, 83%, and 69% for seed moisture contents of, respectively, 27 (at harvest), 20%, 13%, 12%, and 11%.

4. Discussion

Germination, in general, was favored by lower temperatures, both in the light or darkness, even being *E. precatoria* a native species from a tropical region, as such condition is associated with its occurrence in lowland tropical forests, i.e., humid and dense locations, and sites at 600 m altitude [1]. However, when seeds were submitted to light, both germination percentage and germination rate were higher under a larger temperature range, similar to what happens to species growing in dry lands. On the contrary, the alternated temperature at 26°C - 40°C was the most favorable for seed germination of *Bactris maraja*, another palm species that naturally occurs in the same region as *E. precatoria* [12].

Table 1. Germination percentage (%) and germination rate of *Euterpe precatoria* seeds submitted to light or darkness at different temperature conditions.

Temperature	Germination (%)				Germination Rate			
	Light		Darkness		Light		Darkness	
20°C	78.90 ^a (96.29) ^b	aA	78.34 ^a (95.92) ^b	aA	1.616	aB	2.054	aA
25°C	79.16 (96.46)	aA	76.77 (94.76)	aA	1.424	abA	1.075	bB
30°C	75.14 (93.42)	aA	34.87 (32.69)	bB	1.145	bA	0.319	dB
35°C	13.01 (5.06)	bA	2.88 (0.25)	cA	0.070	cA	0.036	dA
20°C - 30°C	81.35 (97.74)	aA	62.27 (78.35)	aB	1.537	abA	0.793	bcB
25°C - 35°C	71.22 (89.64)	aA	42.02 (44.81)	bB	1.238	abA	0.408	cdB
CV (%)	14.86				20.27			

^aData transformed into arcsine (x/100)^{1/2}. ^bNontransformed data. Means followed by the same lower case letters in the column and upper case letters in the line do not differ from each other by the Tukey test at 5% probability.

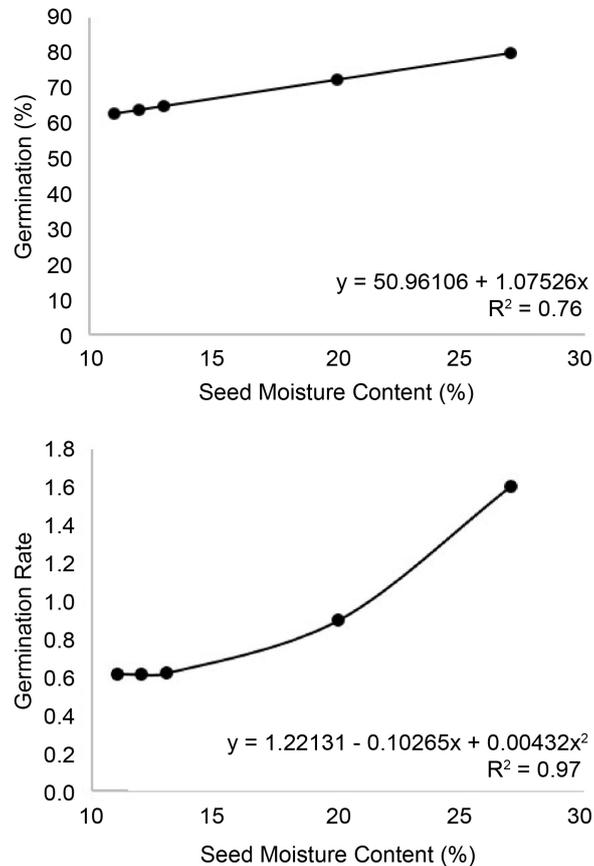


Figure 1. Germination percentage (%) [data transformed into arcsine $(x/100)^{1/2}$] and germination rate of *Euterpe precatorea* according to different seed moisture contents.

Most palms are of tropical origin, with seeds that germinate under higher temperatures. Thus, there are several studies indicating that temperatures falling between 20°C and 40°C are considered generally acceptable for palm seed germination [5]. However, we did not find research results that show higher palm seed germination at 20°C; in fact, such temperature seems to limit germination of some species. For instance, it negatively affects, or completely inhibits, germination of *Syagrus romanzoffiana* [13] and *Archontophoenix cunninghamii* [14]. From a temperature increase to 25°C, best results are observed for *Rhapis excelsa* [15], *Phoenix roebelenii* [16], and *Copernicia prunifera* [17].

It is not possible, therefore, to indicate a general optimum germination temperature for all palms [18], as each genus, or even species, seems to require specific germination environmental conditions according to seed physical and physiological characteristics. The endocarp of *Acrocomia aculeata* seeds, for instance, may act on the seed tolerance to high temperatures, what is an important survival strategy in its natural habitat [19]. This may also happen with *E. precatorea* that showed lowest germination under 35°C, as mean annual temperatures where seeds were harvested fall around 26°C.

About light presence, our results showed that it is not necessary for seed ger-

mination of *E. precatória*, similarly to what was described for other palms, such as *Aiphanes aculeata* [20], *Rhapis excelsa* [15], and *Livistona chinensis* [21]. Furthermore, the dependence of palm seed germination on light is not known [4].

Regarding seed tolerance to low moisture contents, germination percentage of *E. precatória* was high, above 69% regardless drying (up to 11% moisture content), *i.e.*, critical and lethal moisture contents were not observed for this species. Such critical and lethal moisture contents do vary according to the species, but are generally considered high when fall around, respectively, 27% and 38% [22] [23] [24] [25], and 12% and 22% [23] [25] [26] [27]. Additionally, knowledge on seed critical and lethal moisture contents is essential for seed conservation during drying and storage [28].

Although seed germination percentage and germination rate have decreased with moisture loss, *E. precatória* seeds were considered tolerant to low moisture contents. Such tolerance capacity is clearly beneficial as it allows seed persistence for long periods through time in relatively arid environments [29].

Considering the seed classification in orthodox, recalcitrant, and intermediate, the behavior is considered intermediate when seeds survive under moderate drying, generally, up to 12% moisture content [30]; such seeds may then be stored for a longer period in comparison with recalcitrant ones. As most palm seeds are recalcitrant, seed viability is reduced when the moisture content reaches lower values than those considered critical; when such values are equal or lower than lethal ones, there is total viability loss [28] [31] [32] [33].

Critical and lethal seed moisture contents were already indicated for some palm species, such as *Euterpe espirosantensis* (40.7% to 51.4% and 13.4% to 15.8%, respectively) [28], *Euterpe oleracea* (34.2% to 36.4% and 17.4% to 18.9%, respectively) [34], and *Bactris gasipaes* (23.0% to 28.0% and 13.9% to 15.0%, respectively) [35]. However, for *B. gasipaes*, seeds also presented tolerance and lethal levels of 30.0% and 12.0%, respectively [36]; on the other hand, for seeds submitted to lower moisture contents than 38.0%, germination and vigor were rapidly reduced, while 17% moisture content, or lower, promoted a very poor germination [23]. Furthermore, drying did reduce seed germination and vigor of *Bactris maraja* palm when seed moisture content decreased from 23.6% to 7.8% along 15 days [12], while seeds of *Carpentaria acuminata* and *Phoenix canariensis* tolerated drying at 5% and 8% seed moisture, respectively [37]. On the other hand, seeds of *Dypsis decaryi* and *Ptychosperma elegans* were sensitive to dehydration even at high moisture contents, 20% and 27%, respectively [37].

5. Conclusion

For *Euterpe precatória* seeds, the temperature at 20°C promoted highest means of germination percentage and germination rate, under either light or darkness. Seeds were tolerant up to 11% moisture content.

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