Journal of Scientific Research & Reports

27(11): 54-59, 2021; Article no.JSRR.77266
ISSN: 2320-0227

Seed Germination of *Enterolobium contortisiliquum* (Vell.) Morong. (Fabaceae) under Different Temperatures and Drying Method

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2021/v27i1130458
Editor(s):
(1) Dr. Ahmed Mohammed Abu-Dief Mohammed, Sohag University, Egypt.
Reviewers:
(1) Jonathan Titus, SUNY (State University of New York)-Fredonia, USA.
(2) Siti Nurdjanah, University of Lampung, Indonesia.
Complete Peer review History: https://www.sdiarticle4.com/review-history/77266

Original Research Article

Received 09 September 2021
Accepted 18 November 2021
Published 20 November 2021

ABSTRACT

Enterolobium contortisiliquum (Vell.) Morong a tree commonly known as anglerfish, monkey ear and timbaúva. Due to its wood quality, this tree species is widely used in naval and civil constructions, toys and furniture frames, and can also be used for urban afforestation and restoration of degraded areas. The objective of this work was to standardize the best temperature conditions for conducting the germination tests of *E. contortisiliquum* seeds under laboratory conditions, considering the fact that the seeds come from coastal tropical Brazil, and to evaluate the desiccation tolerance. The experiments were carried out at the Plant Propagation Laboratory of the Agricultural Engineering and Sciences Campus (CECA) of the Federal University of Alagoas

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(UFAL), located in the municipality of Rio Largo, Alagoas, Brazil. The design of the experiment was fully randomized, with four repetitions of 25 seeds per treatment. In test I: The newly harvested seeds were subjected to constant temperatures of 5, 10, 15, 20, 25, 30, 35 and 40ºC and alternating temperatures of 20-30ºC, with an eight-hour photoperiod, simulated by four fluorescent lamps 20W daylight type. In trial II: The seeds were divided into two lots. The first was the control (initial moisture content). The second was subjected to slow drying on silica gel. A constant temperature of 30ºC is recommended for the germination and vigor test of *E. contortisiliquum* seeds. The critical means water content for seeds of this species is below 5%.

Keywords: Force; physiological potential; sustainability.

1. INTRODUCTION

Enterolobium contortisiliquum (Vell.) Morong., is a tree species of the Leguminosae-Mimosoideae family, popularly known as anglerfish, monkey ear, timbaúva, among others. Due to its wood qualities, the species is widely used in naval and civil construction, toys and furniture frames, and can also be used in urban afforestation and in the recovery of degraded áreas [1].

The germination process involves a series of metabolic activities, where there is a sequence of chemical reactions that have their own temperature requirements, as they depend on specific enzymatic activities [2]. The germination process can be affected by a series of intrinsic and extrinsic conditions, including humidity, temperature, substrate, light and oxygen. However, the set is essential for the process to take place normally, and the absence of one of them prevents seed germination [3]. Among the conditions that affect the germination process, temperature is considered one of the factors that has significant interference. Temperature variations influence the speed, percentage and uniformity of germination [2].

The drying of seeds, in addition to contributing to the preservation of physiological quality during storage, allows for the anticipation of harvest, avoiding losses of a different nature during the production process. Drying can be done naturally or artificially. When choosing the drying method, the volume of seeds is a limiting factor. In artificial drying, the heat source can be variable. What characterizes the method as artificial is the fact that the process is carried out with the aid of mechanical, electrical or electronic alternatives and air is forced through the seed mass. Natural drying is based on the actions of wind and sun to remove moisture from the seeds. This process is limited by the climate [4].

The choice of the type of packaging for storage is of fundamental importance, as improperly done will affect the viability of the seeds, and it is necessary to take into account: the behavior (orthodox, recalcitrant or intermediate), the environment (normal or controlled conditions) and the time you intend to store the seeds [5]. Thus, the packages are responsible for regulating the exchange of moisture and oxygen between the seed and the environment [6], being classified into: permeable, semi-permeable and impermeable.

Therefore, the objective of this work was to standardize the best temperature conditions for conducting the germination tests of *E. contortisiliquum* seeds under laboratory conditions, considering that the seeds come from coastal tropical Brazil, and to evaluate the desiccation tolerance, monitoring the physiological quality of seeds as a function of different packaging and storage conditions.

2. MATERIALS AND METHODS

2.1 Harvesting and Processing of Seeds

The project was carried out at the Plant Propagation Laboratory, belonging to the Engineering and Agricultural Sciences Campus of the Federal University of Alagoas. The seeds of *Enterolobium contortisiliquum* were collected from mature fruits of trees belonging to small forest fragments located in Alagoas. After harvesting, the seeds were manually separated from the fruits, cleaned and sorted to obtain homogeneous seed size. The determination of the initial moisture content of the seeds was carried out by the oven method at a temperature of 105 ± 3ºC, according to the procedure adopted by the Rules for Seed Analysis [7].

2.2 Overcoming Dormancy, Germination in Diferente Temperatures and Drying Methods

The seeds went through a pre-germinative treatment, which consists of pruning on the opposite side of the micropyle with the aid of a nail clip [8]. Soon after, asepsis was performed, where they were immersed in a 2% (v/v) sodium hypochlorite solution for 10 minutes and then in 70% alcohol (v/v) for one minute, before the beginning of each test and subsequently washed in distilled water.

Test I: The newly harvested seeds were subjected to constant temperatures of 5, 10, 15, 20, 25, 30, 35 and 40 0C and alternating at 20-30ºC, with a photoperiod of eight hours, simulated by four 20 W fluorescent lamps. The precision of the temperature control was in the range of ± 0.5ºC, it was verified germination (GER%), germination speed index (IVG), first count (PC), length (COMP) and dry mass (DM) of seedlings, mean germination time (MT), mean germination speed (VMG), uncertainty (I) and synchrony (Z).

Test II: Seeds were divided into two lots. The first was the control (initial moisture content). The second was subjected to slow drying on silica gel where the seeds were placed in hermetically sealed containers. The loss of water during drying was monitored every 1 hour, the samples were submitted to germination tests (Assay I – optimal temperature). Thus, the degrees of limit moisture and seed security were determined.

2.3 Statistical Analysis

All statistical analyzes were performed using the SISVAR version 5.6 program (FERREIRA, 2011). The design of the experiment was fully randomized, with four repetitions of 25 seeds per treatment. The data obtained submitted to analysis of variance (ANOVA) and the means will be compared by Tukey test at 5% probability. For drying and storage regression was used.

3. RESULTS AND DISCUSSION

The initial moisture content of *Enterolobium contortisiliquum* (Vell.) Morong seeds was 30.26%. For the results referring to the first count (PC) and germination percentage (G) (Table 1), the temperature of 30 ºC provided the highest values. The optimum temperature range for most species is between 20 and 30 ºC [2]. In *Peltophorum dubium* (Sprengel) Taubert seeds, the use of a temperature of 30°C provided the highest number of germinated seeds in the first count [9]. BRACALION et al. [10] reported that the temperature of 30°C was the most favorable for the germination of forest species, with a relationship between the optimal temperature and the biome of occurrence of the species. Among the highest temperatures, 40ºC was the only one that did not allow germination (Table 1). According to Melo Junior et al. [11], temperature is important in the germination process and, when high, can cause a decrease in the supply of free amino acids, protein synthesis and anabolic reactions, negatively affecting the germination process.

Comparing the constant temperatures with the alternating temperature (Table 1), it is observed that the alternating temperature of 20-30ºC provided a good result, with 80 and 92% germination for PC and G, respectively, however statistically lower than 30°C. Similar results were found by Oliveira et al. [12] who found that the alternating temperatures, when compared to the constant ones, showed lower results for germination percentage of *Casearia gossypiosperma* Swartz seeds.

Regarding seed vigor (Table 2), indirectly measured by the speed index (IVG), mean time (TMG) and mean germination speed (VMG), it was noted that the best results were obtained using the temperature of 30 ºC, differing statistically from the other temperatures. Silva et al. [13] studying the effects of temperature on the germination of *Sideroxylon obtusifolium* seeds, (Roem. & Schult.) T.D. Penn. stated that the germination speed is linearly dependent on temperature, being a good index to assess the occupation of a species in a given environment, as rapid germination is characteristic of species whose strategy is to establish itself in the environment as quickly as possible, taking advantage of conditions favorable environmental conditions.

Seeds placed to germinate under constant temperatures of 15, 20, 25 and 35 ºC, and alternating 20-30 ºC showed greater germination uncertainty, not differing statistically from each other, but the temperature of 30 ºC presented the lowest uncertainty, differing statistically from the others (Table 2). In interpreting the germination uncertainty (U), the lower the value, the more synchronized will be the germination, regardless of the total number of seeds that germinate [14].

Table 1. First germination count (PC) and germination (G) of *Enterolobium contortisiliquum* (Vell.) Morong. seeds, submitted to temperatures

Temperature (ºC)	PC (%)	G (%)
5	0 d	0 e
10	0 d	5 e
15	2 d	30 d
20	85 ab	95 b
25	85 ab	95 b
30	97 a	100 a
35	37 c	70 c
40	0 d	0 e
20-30	80 b	92 b
CV (%)	8.12	9.10

Means followed by the same lowercase letter in the column do not differ at 1% probability by Tukey's test

Table 2. Speed index (IVG), mean time (TMG), mean speed (VMG) and uncertainty (U) of germination of *Enterolobium contortisiliquum* (Vell.) Morong. seeds, submitted to temperatures

Temperature (ºC)	IVG	TMG	VMG	U (bit)
5	0.000 e	0.00 f	0.000 f	0.000 c
10	0.105 e	10.00 a	0.100 e	0.000 c
15	0.901 d	7.80 b	0.130 d	1.330 a
20	4.712 b	5.52 cd	0.181 bc	1.152 a
25	4.777 b	5.54 cd	0.181 bc	1.033 a
30	5.500 a	4.00 e	0.250 a	0.232 b
35	3.512 c	6.00 c	0.152 cd	0.900 a
40	0.000 e	0.00 f	0.000 f	0.000 c
20-30	5.100 ab	5.55 d	0.193 b	1.180 a
CV (%)	8.00	7.50	8.12	12.05

Means followed by the same lowercase letter in the column do not differ at 1% probability by Tukey's test

As for the initial development of seedlings, evaluated by the length of the primary root and shoot (Table 3), it was observed that the highest means were reached when used at a temperature of 30ºC. Statistically differing from the others. Probably at that temperature there was a more efficient degradation of the reserves present in the seeds, which ended up favoring the development of the radicles and the aerial part, since at this stage all the development of the seedlings is due to the chemical composition of the seeds [3]. When evaluating the root dry mass (Table 3), the highest value was obtained when 30ºC was used, differing statistically from the other temperatures. Oliveira et al. [15] report that the evaluations of shoot and root dry mass are of great importance in the evaluation of plant development, ensuring the establishment of seedlings in the field.

Table 3. Root length (CR), shoot length (CPA) and dry mass (MSP) of seedlings from *Enterolobium contortisiliquum* (Vell.) Morong. seeds, subjected to temperatures

Temperatura (ºC)	CR (cm)	CPA (cm)	MSP (g)
5	0.00 e	0.00 e	0.000 d
10	0.60 e	1.20 e	0.008 d
15	1.60 d	7.00 c	0.009 d
20	2.50 c	8.00 bc	0.095 b
25	3.00 c	8.40 ab	0.095 b
30	6.00 a	9.50 a	0.140 a
35	0.50 e	5.00 d	0.070 c
40	0.00 e	0.00 e	0.000 d
20-30	3.99 b	9.00 ab	0.100 b
CV (%)	10.05	9.00	9.35

Means followed by the same lowercase letter in the column do not differ at 1% probability by Tukey's test

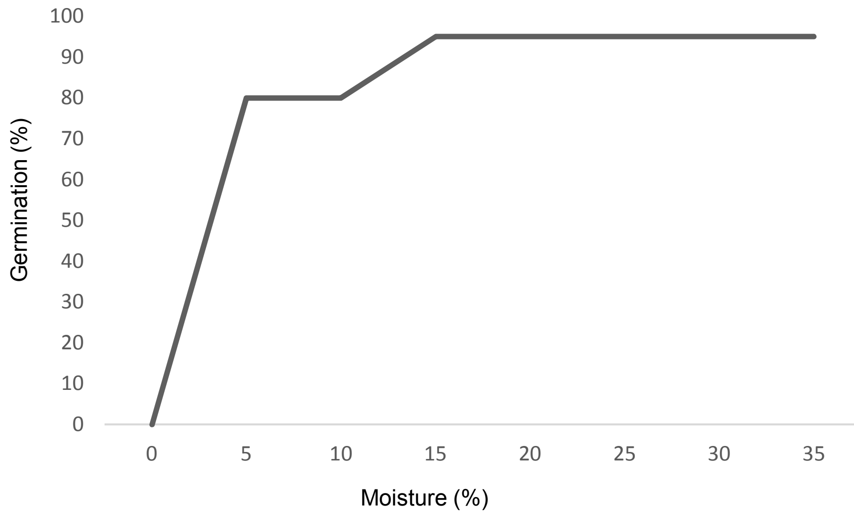

Fig. 1. Average percentage of normal seedlings of *Enterolobium contortisiliquum* (Vell.) Morong. subjected to slow drying on silica gel

The quality of *E. contortisiliquum* seeds was only affected when a water content close to 3.1% was reached, regardless of the speed at which they are dried. Seed drying to levels close to 3% is extremely harmful to the physiological quality of seeds, regardless of the rate at which they are dried, confirming the lethal effect of this water content for seeds of this species (Fig. 1). Based on this, the critical moisture content for seeds of this species is below 5%.

It is noteworthy that the seeds of *E. contortisiliquum*, even after going through the drying stress, still remained viable, with germination above 90%. With this fact, it could be verified that these can be classified as orthodox, considering that they tolerate desiccation at very low humidity levels. Marcos Filho [2] reports that orthodox seeds are those that support dehydration with a water content ranging between 5% and 7%, without, however, losing germination capacity.

4. CONCLUSIONS

A constant temperature of 30ºC is recommended for the germination and vigor test of Enterolobium contortisiliquum (Vell.) Morong seeds.The critical moisture content for seeds of this species is below 5%.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/77266