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INFLUENCE OF LIGHT AND TEMPERATURE ON SEED GERMINATION OF *Macroptilium lathyroides*

INFLUÊNCIA DA LUZ E TEMPERATURA NA GERMINAÇÃO DE SEMENTES DE *Macroptilium lathyroides*

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ABSTRACT

Macroptilium lathyroides is a species of Fabaceae, native to the Guianas, Brazil and Paraguay family. It is a moderately frequent ruderal plant in almost the entire country, infesting mainly orchards, side of roads, lawns and vacant lots. Seeds were collected in soybean fields infested with this plant in Batayporã (MS). Were subsequently reproduced in greenhouse belonging UNEMAT - Alta Floresta - MT. We sought to evaluate the effect of light and temperature on seed germination capacity. For the assay, the seeds were subjected to the presence and absence of light in fixed temperatures 20, 25, 30, 35 and 40 ºC and alternating 15/25, 20/30, 25/35 and 25/40 ºC. The experimental design was completely randomized with four replicates of 25 seeds. Germinated seeds were counted daily, and at the end of 10 daysit was determined IVG, germination percentage, shoot length, root length and dry mass. Seeds of M. lathyroides complete the germination process rapidly and uniformly constant temperatures between 20 and 30 ºC, and alternating temperatures between 15/25, 20/30 and 25/35 ºC.Temperature of 40 ºC leads to delay in this process. The seeds of this species germinate in the presence and absence of light, and is therefore considered positive photoblastic "preferential".

Key words: bean-rice, fig-de-pigeon, leguminous, weed.

RESUMO

Macroptilium lathyroides é uma espécie da família Fabaceae, nativa das Guianas, Brasil e Paraguai. É uma planta ruderal medianamente frequente em quase todo o país, infestando principalmente pomares, beira de estradas, gramados e terrenos baldios. As sementes foram coletadas em lavouras de soja infestadas por esta planta em Batayporã (MS). Posteriormente foram reproduzidas em ambiente protegido pertencente á UNEMAT - Alta Floresta - MT. Buscou-se avaliar o efeito da luz e da temperatura sobre a capacidade germinativa das sementes. Para o ensaio, as sementes foram submetidas à presença e ausência de luz nas temperaturas fixas 20, 25, 30, 35 e 40 ºC e alternadas 15/25, 20/30, 25/35 e 25/40 ºC. O delineamento utilizado foi inteiramente ao acaso, com quatro repetições de 25 sementes. Foram contadas diariamente as sementes germinadas, e no final de 10 dias, determinou-se IVG, percentual germinativo, comprimento da parte aérea, comprimento radicular e massa seca. Sementes de *M. lathyroides*, completam o processo de germinação de forma rápida e uniforme em temperaturas constantes entre 20 e 30 °C, e em temperaturas alternadas entre 15/25, 20/30 e 25/35 ºC. Temperatura de 40 ºC ocasiona atraso neste processo. As sementes desta espécie germinam tanto na presença como em ausência de luminosidade, sendo, portanto, considerada fotoblástica positiva "preferencial".

Palavras-chave: feijão-dos-arrozais, figo-de-pombo, leguminosa, plantas daninhas.

1. INTRODUCTION

Macroptilium lathyroides is a species of the Fabaceae family, native to the Guianas, Brazil and Paraguay [1]. It is a ruderal plant fairly common throughout most of the country,

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

SAJEBTT, Rio Branco, UFAC
v. 7 n. 1 (2020): Edição: jan/abr p. 311-324
ISSN: 2446-4821

infesting mainly orchards, roadsides, lawns and vacant lots [2]. It presents characteristics suitable for moist soils, being able to reach high yields of fodder, with quality. It is not very demanding in fertility, it vegetates in poorly drained places with low pH, besides being adapted to annual rainfall between 630 and 1800 mm [3].

The germinative processes are results of the physiological characteristics of the seed itself and of the environmental conditions of the agroecossystem, promoting a sequence of metabolic activities, which results in the resumption of the development of the embryonic axis [4]. For this reason, some fundamental requirements, such as seed viability and favorable environmental conditions [5] are required.

The temperature is a fundamental factor in the germination of seeds, because it influences the speed of water absorption and the photosynthetic processes that trigger the germination process [4, 6].

Seeds of different species present differentiated responses to germination regarding minimum, maximum and optimal temperature [7]. The germinative processes occur between certain temperature limits, and this potential is expressed more quickly and efficiently according to the residence time of the seeds at the optimum temperature value for each species [8].

The temperature considered optimal for germination is that in which the seed expresses the maximum of germination in the shortest time, being this characteristic defined genetically or as a function of the physiological conditions of the seeds [5, 9].

Knowledge about the optimal conditions for the initial development of weeds becomes fundamental, since it provides information on the propagation of the species [10]. For [11], this knowledge allows clarification of the modifications on the biology of the plants that are under the influence of the adverse conditions of the environment.

In this context, the present research aimed to evaluate the germinative response of *M. lathyroides* seeds as a function of luminosity and temperature.

2. MATERIAL AND METHODS

The experiments were conducted at the Laboratory of Seed Technology and Weed Science (LaSeM) of the Mato Grosso State University, University Campus of Alta Floresta-MT (UNEMAT), Brazil.

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

SAJEBTT, Rio Branco, UFAC
v. 7 n. 1 (2020): Edição: jan/abr p. 311-324
ISSN: 2446-4821

The seeds of *M. lathyroides* were collected in soybeans infested by this plant, in the region of Batayporã (MS). Later they were reproduced in a protected environment belonging to the Mato Grosso State University, Campus of Alta Floresta-MT, aiming the production and collection of seeds for the later studies.

The reproduced seeds were dried and shaded and then stored in paper bags and stored in a cooling chamber at a temperature of 10 ºC (± 2 ºC) until the experiment was installed.

The method used to overcome seed dormancy was immersion in sulfuric acid for 20 minutes followed by washing in running water for 5 minutes [12].

The objective of this study was to evaluate the effect of light and temperature on seed germination capacity, in a completely randomized experimental design with four replicates of 25 seeds, according to a 9 x 2 factorial scheme, ie nine temperature variations: 20, 25, 30, 35 and 40 °C (constant) and alternating 15/25, 20/30, 25/35 and 25/40 °C; and two lighting conditions: presence (in 12-hour light photoperiod) and complete absence.

Acrylic boxes of the gerbox type (11.0 x 11.0 x 3.5 cm) were used, subjected to prior aseptic treatment by cleaning with sodium hypochlorite (10%), two hours before the assembling of the experiments. The seeds were placed to germinate in the acrylic boxes on two sheets of germitest paper moistened with distilled water, in the proportion of 2.5 times the mass of the dry substrate [13], and then conditioned in a BOD germination chamber with a 12-h light regime, using a set of four white bulbs, which provide approximately 0.012 W m^{-2} nm^{-1} [14].

For the light presence condition, the seeds were kept in the BOD chamber in a light regime of 12 hours. In the absence of light, the seeds were kept in the dark throughout the test, involving the gerbox black boxes (11.0 x 11.0 x 3.5 cm) with aluminum foil and transparent plastic film. For counting in the absence of light condition, the number of seeds germinated in a green light chamber was measured, whose wavelength, in the range of 610 and 650 nm, is considered to be safe in evaluations of germination in dark treatments [14, 15].

To characterize the physiological potential of the seeds, the following determinations were performed:

Mean moisture content - Pre-treatments, using the greenhouse method at 105 ± 3 °C, for 24 hours, according to the [13], with three replicates of 50 seeds. The moisture (wet basis) results were expressed as a percentage.

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

SOUTH AMERICAN JOURNAL
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SAJEBTT, Rio Branco, UFAC
v. 7 n. 1 (2020): Edição: jan/abr p. 311-324
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Percentage of germination - The number of germinated seeds was counted daily for a period of ten days [13]. It was considered as criterion for the germination the emission of primary root with length equal to 2 mm [13]. The percent germination calculations were performed according to the formula below:

$$G(\%) = \left(\frac{N}{A}\right) x100$$

where: N = Number of germinated seeds

A = total number of seeds.

Germination speed index (GSI) - It was performed in conjunction with the germination test, the IVG for each sub-sample was obtained according to the formula proposed by [16], presented below:

$$GSI = \frac{N1}{D1} + \frac{N2}{D2} + \cdots + \frac{Nn}{Dn}$$

where: N1: number of germinated seedlings on the day 1,...., n;

D1: days for the occurrence of germination.

Length of aerial part and root of seedlings - They were evaluated together with the germination test, using all normal seedlings of each repetition, measured with ruler graduated in millimeters. The seedling root and shoot lengths, for each sample, were calculated by dividing the total of the measurements by the number of seedlings evaluated, obtaining mean values.

Dry mass of seedling - Defined as the average mass, expressed in grams, corresponding to the mass of each seedlings per repetition, using a drying oven with air circulation, regulated to 65 ± 3 ºC until constant weight, weighing in balance with an accuracy of 0.001 g.

All the results were submitted to analysis of variance and the means were compared by Tukey's test at 5% probability, using the statistical program Sisvar [17].

3. RESULTS AND DISCUSSION

The mean moisture content of *M. lathyroides* seeds was 10.6%. In agreement, [18] also found this same degree of moisture in the seeds of this specie. [5] report that with high

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

moisture content (13-14%) there is high respiration of the seeds, which causes the loss of vigor and eventual falls in germination, and the development of microorganisms may occur both externally and internally. However these same authors stated that with water content between 8-9%, the activity of insects and microorganisms diminish or become zero. Considering the results obtained, with germination above 60% at temperatures between 20 and 30 ºC (Table 1), the initial water content of the seeds is ideal to trigger germination processes for the specie studied.

The data obtained on the germination capacity of *M. lathyroides* seeds under temperature and luminosity variations showed significant differences in the variables analyzed, with interaction between the factors ($p < 0.05$) (Table 1).

Table 1. Germination percentage, germination speed index (GSI) of *Macroptilium lathyroides* submitted to different temperatures in the presence and absence of light

Treatments	Germination (%)		IVG (%)	
	Presence	Absence	Presence	Absence
20 ºC	75 aA	70 abcA	7.78 bcA	6.14 cA
25 ºC	62 abA	70 abcA	7.71 bcA	7.90 cA
30 ºC	70 abA	66 abcA	8.23 bcA	8.22 cA
35 ºC	68 abA	49 cB	9.23 bcA	5.02 bB
40 ºC	22 cA	5 dB	1.04 dA	0.27 dA
15/25 ºC	76 aA	77 abA	10.09 bA	8.58 bcA
20/30 ºC	85 aA	64 abB	13.83 aA	9.96 bB
25/35 ºC	77 aA	80 aA	15.93 aA	12.46 abB
25/40 ºC	53 bA	57 bcA	5.83 cA	4.74 cA
DMS (P/A)	21.03		4.03	
DMS (Temp.)	13.05		2.50	
CV (%)	14.72		22.22	

Means followed by the same lowercase letter in the columns, and upper case in the lines, do not differ by Tukey test at 5% probability.

In relation to temperature, higher germination rates (76 to 85%) were observed at alternating temperatures of 15/25, 20/30 and 25/35 ºC, which did not differ statistically from the constant temperatures 20, 25 and 30 ºC, in general, the most suitable for seed germination

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

of this species. Higher temperatures negatively affected the germination percentage of the seeds, as observed in the 35, 40 and 25/40 ºC regimes.

According to [19], high temperatures can reduce germination, causing disorganization of the germination process, being that the number of seeds that can complete this process decreases rapidly, basically due to the effects on the activity of enzymes and the restrictions on the oxygen access. In agreement, [20] reported that for the majority of species, the optimum temperature is between 20-30 ºC, and that both values below and above this temperature can lead to a reduction in the speed of the process as well as in the total germinated seeds.

It was verified that at constant temperatures of 20, 25 and 30 ºC and alternating 15/25, 25/35 and 25/40 ºC, there was no significant interference for the presence or absence of light. However at 35, 40 and 20/30 ºC, germination responded better in the presence of light.

Similarly, [21] concluded that light was not a factor promoting variations in seed germination of the invasive plant *Murdannia nudiflora*, which can germinate satisfactorily both in the presence and absence of light. [22] and [23], report germination even in absence of luminosity in seeds of *Porophyllum ruderale* and *Emilia coccinea* respectively, stating that this may be an indicative factor of preferential photoblastism. Too [24] found a higher percentage of emergence of *Tecoma stans* in the sun environment (86%), although in the shade there was also an emergency of 69%.

According to the response to light, the seeds are classified into three main groups: positive photoblasts (germinate with light), negative photoblasts (not germinating with light) and also those that present indifferent or insensitive behavior to light are nonphotoblastic or neutral [4]. In this classification, [26], called the positive photoblastic character of "preferential" when some germination occurs in the absence of light and "absolute" when the germination is totally zero in the absence of light. Thus, the species under study, based on this classification, behaved as preferential positive photoblastic.

According to [27], the non-influence of light on the germinative processes of some weeds, indicate a strategy to occupy other niches or to form denser populations, since their propagules can germinate even under low temperature conditions. According to [28] and [29], the majority of plant species have the ability to acclimatize to certain variations in temperature and luminosity. Seed germination of *M. lathyroides* appears to normally occur at most of the temperatures tested, revealing its potential for infestation in environments with large thermal amplitudes with absence or presence of light.

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

At the higher temperatures (40 °C and 25/40 ºC), most of the seedlings obtained were considered abnormal, presenting the primary root undeveloped and epicotyl short and necrotic, also affecting the speed index of seed germination. For this variable, the alternating temperatures of 20/30 and 25/35 ºC provided the highest homogeneity of the seedlings. These data lead to the realization that, in *M. lathyroides* seeds, the germination speed is a more sensitive factor to the variations of continuous temperatures when compared to the alternating ones.

Likewise, [18] studied different germination and constant temperatures in the germination of *M. lathyroides* and reported a higher germination index in the presence of alternating temperature (20/30 ºC).

Of course, temperature variation occurs especially in regions between the tropics. The highest temperatures are recorded after 13 hours and the lowest temperatures during the dawn [30]. This thermal amplitude may interfere with the germination of rustic species, including many weeds, including those with some type of dormancy [31].

Seeds of several species require daily temperature variation to obtain optimum germination. The need for this temperature variation during germination is associated with seed dormancy, however, there are also reports that this variation may accelerate the germination process of non-dormant seeds [32].

[33] stated that the necessity of this variation is associated with changes in the permeability of seed coat to water and gas exchange. Thus, temperature alternation may interfere with the balance between promoting substances and inhibitors of dormancy [34].

According to [34] and [35], observed that species of *Digitaria* and *Amaranthus*, respectively, presented with more favorable results for percentage and germination speed in alternating temperature regimes. Likewise, [36] observed maximum germination under these conditions for *Synedrellopsis grisebachii*. At constant temperatures of 20, 25, 30, 40 ºC and alternating 15/25 and 25/40 ºC, there was no interference of the luminosity, but when exposed to temperature regimes of 35, 20/30 and 25/35 ºC, the largest germination rates were obtained in the presence of light. These results reaffirm the preferential positive photoblastosis of *M. lathyroides* seeds.

This ability to germinate under conditions of thermal amplitude and luminosity can aid in the explanations of the great densities of this weed in areas of corn and soybean cultivation [37], including under no-tillage system, whose seeds are under light incidence and even covered by layers of straw.

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

SAJEBTT, Rio Branco, UFAC
v. 7 n. 1 (2020): Edição: jan/abr p. 311-324
ISSN: 2446-4821

For the specific case of the variables in question, it is important to observe that, although it presents greater germination in the presence of light, also occurs a high germinative percentage in its absence. This fact supports the finding that this species is, in many cases, an infestant that emerges late within the summer crop cycle, which makes its control difficult [38]. Although germination occurs both in presence and absence of light, the lowest germination in the dark can be used as a cultural control tool of the species. As for example, the effect of altering the line spacing as a function of the shade provided by the crop may be a potential tool for the cultural control of this species [39].

The development of *M. lathyroides* seedlings was influenced by temperature and luminosity, and the interaction between the factors ($p < 0.05$) was also observed (Table 2).

Table 2. Length of part area and root length of *Macroptilium lathyroides* submitted to different temperatures in the presence and absence of light

Treatments	Length of part area (mm)		Root length (mm)	
	Presence	Absence	Presence	Absence
20 ºC	45.39 abcB	85.21 bA	26,09 aA	12,73 aB
25 ºC	57.63 abB	92.67 abA	12,65 cdA	10,12 abcA
30 ºC	56.17 abB	83.48 bA	10,84 cdeA	10,91 abcA
35 ºC	53.31 abB	81.23 bA	8,23 defA	5,53 bcdA
40 ºC	21.37 cB	34.99 dA	3,22 fA	1,49 dA
15/25 ºC	53.08 abB	100.22 aA	15,98 bcA	10,00 abcB
20/30 ºC	52.59 abB	99.29 aA	19,07 bA	11,47 abB
25/35 ºC	58.66 aB	87.00 abA	10,99 cdeA	10,47 abcA
25/40 ºC	44.20 bcB	59.84 cA	5,45 efA	5,02 cdA
DMS (P/A)	13.77		6.41	
DMS (Temp.)	8.54		3.97	
CV (%)	9.30		26.55	

Means followed by the same lowercase letter in the columns, and upper case in the lines, do not differ by Tukey test at 5% probability.

As for the length of the aerial part of the *M. lathyroides* seedlings (Table 2), it was verified that this variable was influenced by temperature and luminosity, with the interaction between these two factors ($p < 0.05$).

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

SAJEBTT, Rio Branco, UFAC
v. 7 n. 1 (2020): Edição: jan/abr p. 311-324
ISSN: 2446-4821

The treatments maintained at constant temperatures of 20 to 35 ºC and alternating of 15/25, 20/30 and 25/35 ºC provided a longer shoot length in the presence of light, with no differences between them. In the absence of luminosity, greater lengths were observed in the alternating temperatures 15/25, 20/30 and 25/35 ºC, followed by 25 ºC, which differed statistically from all other temperatures studied. However, when the seeds were kept at 40 and 25/40 ºC in both conditions of luminosity, there was a marked decrease in the length of the aerial part of the seedlings, demonstrating the negative influence of this high temperature on this variable.

When comparing results obtained under absence and presence of light, a positive effect of light absence was observed, reaching up to 100.22 mm of shoot length (Table 2). The elongation of the stem is due to the lack of luminosity during the development of *M. lathyroides* seedlings. Small seeds have little energy reserve and generally need to germinate faster in search of light to carry out their photosynthetic processes and become autotrophic plants [40].

In relation to the results obtained in the root length, it can be observed that when placed to germinate at 20 ºC, followed by 20/30 and 15/25 ºC in the presence of light, the seeds found conditions to give rise to seedlings with higher growth rate (up to 26.09 mm), possibly due to the greater capacity of conversion and transformation of seed reserves into new formed tissues, as reported by [41].

Lower values were observed at temperatures of 40 and 25/40 °C. Thus, since the treatments were not efficient in the germination of the seeds, they had a negative response to the length of seedlings. In the absence of light, the largest root length was 12.73 mm at 20 ºC, not differing from the constant heat treatments of 25 and 30 ºC and alternating 15/25, 20/30 and 25/35 ºC. High temperatures (35, 40 and 25/40 ºC) caused a decrease in the root length of the seedlings of this species.

High temperatures tend to accelerate and disrupt the germination process of the seeds [5], causing a reduction in the growth rate of the shoots and also of the root part [42].

In addition to the effect of light on root development, there was a tendency for seeds under light to have a higher root length than those maintained without light, as can be observed in Table 2.

The results concerning the weight of dry mass (Table 3) indicate that there were interaction of temperature and luminosity factors.

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

SOUTH AMERICAN JOURNAL
of Basic Education, Technical and Technological

SAJEBTT, Rio Branco, UFAC
v. 7 n. 1 (2020): Edição: jan/abr p. 311-324
ISSN: 2446-4821

The highest accumulation of dry mass occurred when the seeds were submitted to constant temperatures of 20 to 35 ºC and alternated of 15/25 to 25/40 ºC in the presence of light, differing from the temperature of 40 ºC.

Table 3. Dry mass of *Macroptilium lathyroides* seedlings submitted to different temperatures in the presence and absence of light.

Temperatures (ºC)	Dry mass (g)	
	Presence	**Absence**
20	0.00345 aA	0.00337 aA
25	0.00277 aA	0.00172 bcB
30	0.00295 aA	0.00092 cdB
35	0.00325 aA	0.00082 cdB
40	0.00042 bA	0.00062 dA
15/25	0.00262 abA	0.00250 aA
20/30	0.00297 aA	0.00067 dB
25/35	0.00280 aA	0.00132 cdB
25/40	0.00260 aA	0.00172 bcB
DMS (P/A)	0.0009	
DMS (Temp.)	0.0006	
CV (%)	20.79	

Means followed by the same lowercase letter in the columns, and upper case in the lines, do not differ by Tukey test at 5% probability.

It was also verified that at 20 ºC in the absence of light, the response for the dry mass variable was higher, followed by 15/25 ºC. This result fell 87.82% and 81.60% in the presence and absence of light, respectively, when under a temperature of 40 ºC. These results demonstrate the sensitivity of the seeds when exposed to high temperatures. In general, elevated temperatures lead to a decrease in the supply of free amino acids, RNA and protein synthesis, and the slowing down of metabolic reactions [43].

The luminosity did not interfere with the accumulation of dry matter at temperatures of 20, 40 and 15/25 ºC, and in the other thermal regimes tested, the presence of light promoted greater accumulations of dry mass.

In most of the light and temperature conditions, indicated as the best in the germination pattern of this species, there was a greater accumulation of dry mass of the

Enviado em: 30/08/2019 - Aprovado em: 24/01/2020

SAJEBTT, Rio Branco, UFAC
v. 7 n. 1 (2020): Edição: jan/abr p. 311-324
ISSN: 2446-4821

seedlings. Under optimal conditions of germination, seeds with higher vigor present higher capacity of transformation of the reserve supplies of the storage tissues and, consequently, greater incorporation of these by the embryonic axis [44], resulting in seedlings with greater accumulation of dry mass [45].

CONCLUSIONS

Seeds of *Macroptilium lathyroides* complete the germination process quickly and uniformly at constant temperatures between 20 and 30 °C, and alternating temperatures between 15/25, 20/30 and 25/35 °C. Temperature of 40 °C causes delay in this process.

The seeds of this species germinate both in the presence and absence of luminosity, but prefer the light condition, being therefore considered preferential positive photoblast.

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