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Germination of amaranth seeds under influence of light, substrate and temperature

Germinação de sementes de amaranto sob influência da luz, substrato e temperatura

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ABSTRACT

Seed germination involves complex physiological and biochemical mechanisms. The cultivation of amaranth, of great food importance, lacks information about this process. The aim of this study was to evaluate the effect of temperature, light and different substrates on the germination of amaranth seeds. The experimental design was entirely randomized in a trifactorial scheme, with two temperatures, two conditions of light and four substrates, with four repetitions of 100 seeds each. The percentage of seed germination was evaluated until 24 days of implementation and the cumulative germination at 07, 14 and 24 days. The germination began on the fourth day for the substrate between sand and for the other substrates it began on the eleventh day, stabilizing in the fourteenth day. There was triple significant interaction among temperature, light condition and substrate factors used on the germination test. The best condition for amaranth seed germination is at a 25 ºC temperature, in the absence of light and on paper roll substrate, with 87% of germination. These conditions can be used in germination tests for seed lots, to test its quality.

KEYWORDS: *Amaranthus caudatus*, physiological seed quality, seed analysis.

RESUMO

A germinação das sementes envolve complexos mecanismos fisiológicos e bioquímicos. A cultura do amaranto, de grande importância alimentar, carece de informações quanto à este processo. O objetivo deste trabalho foi avaliar o efeito da temperatura, da luz e de diferentes substratos sobre a germinação de sementes de amaranto. O experimento foi realizado em esquema trifatorial, sendo duas temperaturas, duas condições de luz e quatro substratos. Adotou-se o delineamento experimental inteiramente casualizado, com quatro repetições de 100 sementes cada. Foi avaliado o percentual de germinação das sementes até 24 dias da implantação e a germinação acumulada aos 07, 14 e 24 dias. A germinação teve início no 4° dia para o substrato entre areia e para os demais substratos teve início no 11° dia, estabilizando-se no 14° dia. Houve interação tripla significativa entre os fatores temperatura, condição de luz e substrato utilizado no teste de germinação. A melhor condição para a germinação de sementes de amaranto é na temperatura de 25 ºC, na ausência de luz e em substrato rolo de papel, com 87% de germinação. Estas condições podem ser utilizadas em testes de germinação de lotes de sementes para atestar sua qualidade.

PALAVRAS-CHAVE: *Amaranthus caudatus*, qualidade fisiológica de sementes, análise de sementes.

Amaranth (*Amaranthu*s sp. L., Amaranthaceae family) is considered a pseudo-cereal, it stands out for its variety of uses and for presenting superior quantities of proteins, fibers, vitamins C and A, and minerals if compared to most grain cereals (AMAYA-FARFAN et al. 2005, MARCÍLIO et al. 2005).

Amaranth is still practically unknown in the Brazilian agriculture, although it showed to be a viable alternative. It can be cultivated during the fall season or the off-season (winter) of the soybean and/or corn production in the counties of the Brazilian Cerrado, due to water restriction tolerance, high biomass and short cycle grain production (SPEHAR et al. 2003, TEIXEIRA et al. 2003). Therefore, it is a crop that should be better used in Brazil, including for soil coverage under no-tillage.

Although the Rules for Seed Analysis (BRASIL 2009) establish criteria for germination tests and

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quality control for amaranth seeds, few studies were done involving its seed technology. These studies are important to guarantee seed lots with the quality necessary for commercialization, storage and/or sowing.

Therefore, this study aimed to evaluate the effect of temperature, light and different substrates on amaranth seed germination in laboratory conditions.

The amaranth seeds used as experimental material were non-certified seeds, from the 2012/2013 crop, that were produced by a family farmer in the county of Ipê, RS. An average sample of the seed lot, weighing 1.0 kg was sent to the laboratory for identification and then it was placed in a cold and dry chamber at 10 °C and 20% relative humidity, until its physical characterization and assay development.

Following the Rules for Seed Analysis – RAS recommendations (BRASIL 2009), the assay was properly homogenized for the work samples withdrawal. In the physical characterization sample, the weight of a thousand seeds (0.96 g) and the initial water content (14,1%) of the lot were estimated through the greenhouse method at 105±3 ºC. The seeds used to conduct the assay were taken from the pure seed fraction.

The experiment consisted of the evaluation of amaranth seeds germination under the effect of two temperatures (18 and 25 °C), two light conditions (absence of light and photoperiod of 12/12 hours) and four substrates (between paper, on the paper, paper roll and between sand), in a trifactorial scheme (2x2x4). The experimental design was entirely randomized with four repetitions of 100 seeds. For the evaluations that involve substrates between paper (EP), on the paper (SP) and between sand (EA), the repetitions were allocated in transparent polypropylene boxes (gerbox). In the paper roll (RP) substrate, the seeds were placed between two paper sheets of Germitest® that after wrapping were protected with a plastic film to avoid humidity loss. For the substrates between paper and on the paper blotter papers were used. The substrates were slightly wet with distilled water, with twice and a half of the volume of the substrate weight used. The tests were allocated in BOD (Biological Oxygen Demand) chambers.

The percentage of seed germination was evaluated daily and recorded 24 days after implementation, after verification and stabilization in all treatments determined by the speed of emergency index (IVG), according to methodology proposed by NAKAGAWA (1999). The percentage of cumulative germination was calculated at 07, 14 and 24 days.

The results were submitted to Lilliefors normality test, without the need to transform them. Then, the variance analysis was applied to verify the significance of the factors and its interactions. The Tukey test ($p \leq 0{,}05$) was also applied to compare the means of the treatments. All of the analyses were executed with the help of Assistat statistical software.

The amaranth seed germination for the substrate EA began on the fourth day and for the other substrates it began on the eleventh day, starting to stabilize at 14 days for all substrates, although it had been observed until 24 days. Similar results are described in RAS (BRASIL 2009), where it's recommended 4-5 days for the first count and 14 days for the final count. The seed germination for the sand substrate started a week earlier compared to the paper substrates. This substrate can represent an advantage since the germinating seeds are less exposed to fungi degradation that can lead to an unfeasible embryo.

With seeds of the same species under greenhouse conditions, COSTA & DANTAS (2009) verified that the three types of sand substrates and two types of soil propitiated the germination to begin at the 3° and 4° day after sowing, although, they observed that this emergence stabilized faster compared to the present work at the 6° day after sowing.

There was a significant triple interaction between temperature, light condition and substrate used on the amaranth seed germination. The higher germination percentage was obtained at a 25 °C temperature, combined with RP substrate and in the absence of light (87% germination) (Table 1), which did not differ significantly from the combination temperature at 25 °C, with light and on the substrate EP (72% germination). The first combination of germination conditions is the most economic because for the RP substrate the use of gerbox, light and BOD chamber isn't necessary. Depending on the laboratory's environmental conditions, the temperature of 25 ° C may be easier to achieve than 18 °C.

In general, the amaranth seeds had higher germination at a 25 °C temperature if compared to the 18 °C temperature. However, the only exception was when the RP substrate was used in the presence of light, in which the 18 °C temperature had higher seed germination, differing significantly from the 25 °C temperature (Table 1). Using the 18 °C temperature, it was observed that in the absence of light the

Table 1 - Germination percentage of amaranth seeds (*Amaranthus caudatus* L.) in function with the interaction among the temperature, photoperiod and substrate factors.

Temperature	Photoperiod x Substrate							
	Without light x EP	Without light x SP	Without light x RP	Without light x EA	With light x EP	With light x SP	With light x RP	With light x EA
25 °C	11 aD	47aC	87aA	61aBC	72 aAB	65 aBC	48 bC	56 aBC
18 °C	0 bC	0 bC	0 bC	0 bC	1 bC	4 bC	67 aA	45 bB

Means followed by different letters, capital letters on the line and lower case letters on the column, differ by the Tukey test (p≤0,05). CV(%) = 27,8. EP: between paper; SP: on the paper; RP: paper roll; EA: between sand. With light: represents a photoperiod of 12 hours.

germination is null in all substrates and very low in the presence of light with the substrates EP and SP. In this temperature the germination became higher when light and the two substrates that covered the seeds RP (67% germination) and EA (45% germination) were used, this can be the consequence of higher water retention and better temperature homogeneity of the substrates.

According to RAS the ideal temperature for *Amaranthus* sp. seed germination is 20 °C or alternately 20-30 °C (BRASIL 2009). In the present work, it was observed that in most combinations of photoperiod x substrate the amaranth seeds had higher germination at a 25 °C temperature if compared to an 18 °C temperature. This result demonstrates that soil temperature for amaranth seed sowing should be around 25 °C to benefit seedling emergence, which coincides with temperatures from mid-spring and summer in the South region or even in the fall and winter in the Brazilian Midwest region (TEIXEIRA et al. 2003).

RAS (BRASIL 2009) informs the SP substrate as being the best condition for amaranth seed germination. For *Celosia cristata* L. (Amaranthaceae) seeds the substrates between paper and on the paper provided higher germination percentages (49,1 to 57,0%) if compared to the substrates between and on the sand, coconut dust and vermiculite at a 25 °C temperature and continuous light (FERREIRA et al. 2008). These results differ from the present work indicating that other factors besides the substrate influenced on seed germination, such as temperature and light, emphasizing the triple interaction that occurred among these factors in this work.

Higher germination values were obtained in the combination of a 25 °C temperature, absence of light and on RP substrate and in the combination of 25 °C, in the presence of light and on the EP substrate, emphasizing again the interaction among factors that interfere with germination. However, previous work with *Amaranthus caudatus* seeds verified an increase on the germination in the absence of light at temperatures of 35 °C and, in other words, photoblastic negative (GUTTERMAN et al. 1992).

When evaluating the cumulative germination percentage, it is possible to get an idea of seed germination speed. Figure 1 shows the cumulative germination average at 07, 14 and 24 days, in function of substrates and temperature.

At the temperature of 25 °C there was a higher seed germination speed especially for the RP and SP substrates. There was satisfactory germination at 7 days for the substrate EA without light and for the substrates RP and SP with light. Thus, it is clear that the speed of germination tended to be lower in the absence of light. However, after 14 days, there wasn't a significant difference between the presence or absence of light, a difference was seen only between the substrates tested. The speed of germination under a 18 °C temperature was slower and some substrates didn't germinate until the end of the evaluation period.

CARVALHO & CHRISTOFFOLETI (2007) found that light and temperature interfered on the germination of five species of weeds from the *Amaranthus genus*. These authors affirm that higher germination speed occurred in a photoperiod condition with temperature alternation, which is the predominant condition on the field, in other words, the species are able to germinate in most agronomic situations.

In general, the studies show higher levels of germination speed of these weeds in a condition with temperature alternation, especially when the alternation was done around 20, 25 or 30 ºC

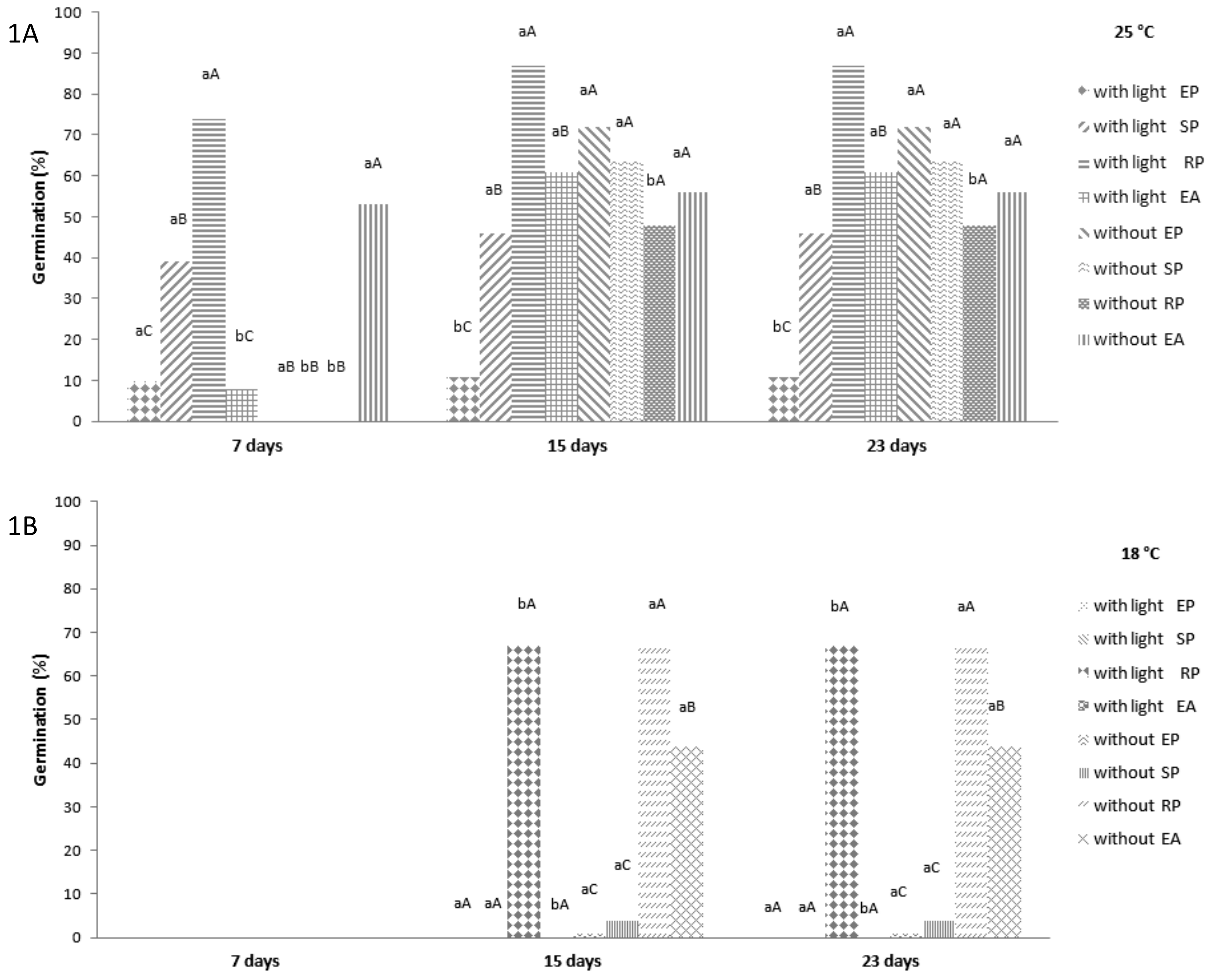

Figure 1 - Cumulative percentages of *Amaranthus caudatus* L. seed germination in function with the interactions among temperature, photoperiod and substrate factors.

Means followed by different letters, capital letters for photoperiod and lower case letters for substrates, differ by the Tukey test (p≤0,05). EP: between paper; SP: on the paper; RP: paper roll; EA: between sand. With light: represents a photoperiod of 12 hours.

(STECKEL et al. 2004).

New studies should be conducted to increase the knowledge about amaranth seed performance considering its potential of crop growth in Brazil. Information about various aspects of its cultivation is still unknown especially in relation to seed pathology. Possibly studies involving other aspects of amaranth seed germination in laboratory and field conditions could provide aids to improve the quality of seed lots that will be planted.

Finally, a 25 ° C temperature is recommended for amaranth seed germination, with paper roll or between paper substrates, being better in the presence of light.

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