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Germination and growth of *Albizia niopoides* (Bentham) Burkart (Fabaceae)

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ABSTRACT. *Albizia niopoides* (Bentham) Burkart, known as *farinha seca*, is an arboreal, deciduous and pioneer plant that can be found in the semi-deciduous forest in the Paraná basin. The study on the germination and growth of the plant is fundamental for better knowledge about the establishment and regeneration of the species. Aiming to verify the germination of *A. niopoides* and subsequent growth, green seeds and brown seeds were germinated in a germination chamber and growth parameters were evaluated at 60, 90, and 180 days after transplanting (DAT) in a greenhouse. There was no significant difference in germination percentage between green and brown seeds. However, lower levels of mean germination times and higher levels of germination speed index were observed for brown seeds. At 180 DAT, plants showed higher shoot dry mass, root dry mass, total dry mass, number leaves and height, with no significant difference between 60 and 90 DAT for total dry mass, root dry mass and root length. The values of stem height/diameter and Dickson quality index, associated to the other growth parameters, indicate quality of the seedlings for field planting at 180 DAT.

Keywords: establishment; dry matter; green seeds; brown seeds.

Germinação e crescimento de *Albizia niopoides* (Bentham) Burkart (Fabaceae)

RESUMO. *Albizia niopoides* (Bentham) Burkart, conhecida como farinha-seca, é uma planta arbórea, decídua, pioneira e ocorre em floresta semidecídua da bacia do Paraná. O estudo sobre a germinação e crescimento das plantas é fundamental para o maior conhecimento acerca do estabelecimento e regeneração das espécies. Com o objetivo de verificar a germinação de *A. niopoides* e seu posterior crescimento, sementes verdes e castanhas foram germinadas em câmara de germinação e foram avaliados os parâmetros de crescimento aos 60, 90 e 180 dias após o transplante (DAT) em casa de vegetação. Não houve diferença significativa em relação à porcentagem de germinação entre sementes verdes e castanhas; no entanto, foi observado menor tempo médio de germinação e maior índice de velocidade de germinação para sementes castanhas. Aos 180 DAT as plantas apresentaram maior massa seca da parte aérea, massa seca da raiz, massa seca total, número de folhas e altura, não ocorrendo diferença significativa entre os 60 e 90 DAT, em relação aos parâmetros massa seca total, massa seca da raiz e comprimento da raiz. Os valores da razão altura/diâmetro do coleto e índice de qualidade de Dickson, associados aos demais parâmetros de crescimento, indicam qualidade das mudas para o plantio a campo aos 180 DAT.

Palavras-chave: estabelecimento, matéria seca, sementes verdes, castanhas.

Introduction

The life cycle of superior plants involves the development of the seed, followed by germination and the subsequent growth of the plant (Castro, Bradford, & Hilhorst, 2004). For most seeds, the development can be divided into three phases, the latter being desiccation. However, the ability of the embryo to germinate develops early if the seed is removed from the fruit early, even before the maximum dry matter is obtained.

The initial developmental period of a plant is considered critical in the life cycle of many plant species (Kircher & Schopfer, 2012). Because of this, studies that relate seed morphology and germination have been intensified, providing useful subsidies for nursery work, seed storage, and regeneration of forests (Souza & Oliveira, 2004).

Germination determines the distribution of plants, and the study of the ecology of this process and knowledge about seed biology may be of great value in understanding the stages of establishment of a plant community, as well as its survival and natural regeneration (Garcia & Diniz, 2003). This is a complex process and depends on several factors, such as temperature, light, water, and composition of gases in the atmosphere (Cabral, Barbosa, & Simabukuro, 2003).

The effect of temperature on germination is especially important for the ecology of populations. For spores and seeds to be able to germinate, their cardinal temperatures must correspond to external conditions that ensure rapid development sufficient for young plants (Bewley, Bradford, Hilhorst, & NonogakiI, 2013). In addition, the effect of temperature on germination can be evaluated from changes in percentage, rate, and relative frequency of germination over the incubation time (Marcos Filho, 2005).

The maturity of the seed comprises the morphological, physiological, and functional transformations that occur in the fertilized egg, culminating in the point of the seed's greatest dry matter. With this, the seed also reaches the maximum germinative capacity and health, which is called the 'point of physiological maturity' (Popinigis, 1985). Thus, physiological maturity would be associated with maximum health and percentage of germination, indicating the ideal harvest point (Aguiar, Pinto, Tavares, & Kanashiro, 2007). Nobre et al. (2012) relate the physiological quality of the seed to its capacity to present greater longevity, germination, and health.

Several authors have carried out studies associating seed coat coloration with seed physiological maturity, germination capacity, and health (Silva, Aguiar, & Figliolia, 2008; Alves et al., 2013). According to Souza and Marcos Filho (2001), the coat is one of the main determinants of germination, health, and longevity of the seeds, and its study can contribute to explain the behavior of the seed in the environment.

Carvalho (2009) reports that *A. niopoides* presents coat-imposed dormancy, and that the seeds need to be immersed in 75% sulfuric acid to germinate. The coat-imposed dormancy of this species is also reported by Kissmann, Scalon, Mussury, and Roabina (2009). However, there is empirical knowledge by rural farmers that green and untreated seeds of *A. niopoides* germinate just as well as the brown seeds.

Albizia niopoides (Bentham) Burkart, Fabaceae, popularly known as *farinha seca*, is a deciduous and pioneer tree species, which can be found typically in semi-deciduous forest of the Paraná basin. It is an excellent plant for restoration of degraded areas (Lorenzi, 2000). According to Kissmann et al. (2009), this species can reach 10 to 20 m high, has ornamental properties, and can be used in public squares and large gardens.

For the establishment of protocols that allow the use of native species in programs for the restoration of degraded areas (as well as for commercial plantations) studies on ecophysiology are necessary in field conditions, under controlled laboratory conditions, in semi-controlled conditions without nurseries, and in greenhouses. For the production of seedlings, morphological parameters have been used that can indicate the quality of the plants considering their survival after planting in the field (Bernardino, Paiva, Neves, Gomes, & Marques, 2005). Among the most important parameters in the evaluation of plant growth are shoot and root biomass (Ramos, Felfili, Souza-Silva, & Franco, 2004). In addition, other parameters such as shoot diameter, height /shoot diameter and root/shoot dry matter ratio may help in the selection of morphological patterns that can ensure success of the seedlings in the environment (Gomes, Leite, Xavier, & Garcia, 2002; Bernardino et al., 2005; Gomes & Paiva, 2006; Delarmelina, Caldeira, Faria, Gonçalves, & Rocha, 2014).

Thus, this study aimed to evaluate the germination of green and brown seeds of *A. niopoides*, and the growth parameters of young plants of this species.

Material and methods

The work has conducted in the Laboratory of Plant Physiology and in a greenhouse of the Didactic Garden of the Department of Biology. Fruits of *A. niopoides* were harvested from six individual trees when they were starting the process of natural dehiscence, in October 2013. The harvest occurred in the *Estação Ecológica do Caiuá*, (52º 49' - 52º 53' W and 22º 34' - 22º 37' S), located in the municipality of Diamante do Norte, State of Paraná. After harvesting the fruits, they were transported in black plastic bags to the laboratory, where pods were opened manually to obtain the seeds. Seeds were separated into two classes of coloring (green and brown) (Figure 1), the germination tests were carried out, the dry matter was obtained, and the greenhouse growth analysis was performed.

For germination analysis, seeds were placed on a Petri dish, containing two filter paper disks, moistened with distilled water. The experiment was conducted in a germination chamber maintained at 25ºC and with a photoperiod of 12 hours. There were four replicates of 25 seeds each. This procedure was performed for both green and brown seeds. The germination tests occurred at 25°C, as work done by Brancalion, Novembre, and Rodrigues (2010) and Kissmann et al. (2009) attested that this temperature is ideal for *A. niopoides.* The evaluations occurred every 24 hours, considering the protrusion of radicles as a germination criterion. Germination percentages (%G), mean germination times (MGT), and germination speed index (GSI) were calculated according to Maguire (1962) and Ferreira and Borghetti (2004).

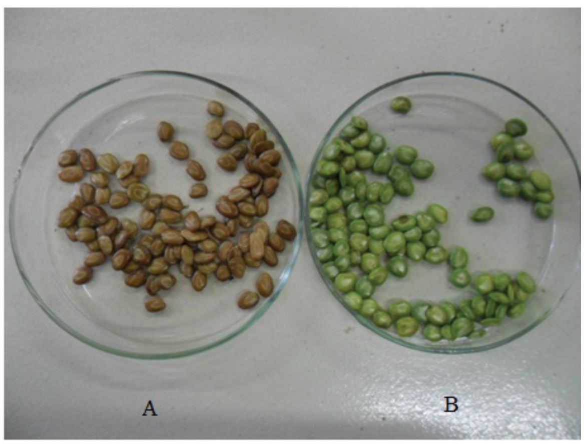

Figure 1. Brown (A) and green (B) seeds of *Albizia niopoides*.

Seeds not used for the germination and growth tests were used to obtain the degree of moisture and dry matter (DM), and were determined by the greenhouse method at 105 ± 3°C for 24 hours, with accordance to Brasil (2009), using four replicates of 20 seeds, both for green and brown seeds.

For seedling evaluation, green and brown seeds were placed on Styrofoam trays, containing sand and soil as a substrate, in the proportion of 2:1. Time for the emergence of the seedlings was determined, and after 15 days, the height of the aerial part (H) and the length of the root (LR) were measured.

Plant growth occurred in a greenhouse, where seedlings were transferred to pots containing the proportion of 2:1 sand and soil as a substrate, and irrigation was provided daily. For growth analysis, plants were removed from the pots at 60, 90, and 180 days after transplanting, where we evaluated the height of the aerial part (H) and root (LR), number of leaves (NL), shoot (SDM), root (RDM), and total (TMD) dry mass and shoot dry mass/root dry mass ratio (SDM/RDM). The stem diameter (D) and Dickson quality index (DQI) was obtained at 180 days. Based on these morphological parameters, we calculated stem height/shoot diameter (H/SD). To obtain the dry matter, plant material was separated into aerial and root portion and kept in a drying oven at 60°C for 48 hours. After this period, the mass was obtained using a precision scale.

The results of the germination and emergence were tested by analysis of variance and when significant, Tukey's test was applied for the comparison of means, at 5% significance. Young plants were obtained randomly because in previous analysis there was no significant difference between the plants originated from brown or green seeds, and the growth parameters were compared according to DAT and the means compared by the Tukey's test at 5%.

Analyses of variance were run using Sisvar (System for Analysis of Variance) software.

Results and discussion

Green seeds presented higher fresh mass and water content, but no significant difference was detected between green and brown seeds in relation to dry matter (Table 1). There was also no difference between seedlings from green and brown seeds in relation to shoot height and number of leaves, although seedlings from brown seeds had a longer root length.

Table 1. Fresh seed mass, Dry seed mass, Seed water content and germination and emergence parameters in *Albizia niopoides* (Bentham) Burkart (Fabaceae).

Parameters	Color of the coat	
	Green	Brown
Fresh seed mass (g)	1.859a*	0.818b
Dry seed mass (g)	0.779a	0.756a
Seed water content (%)	58.012a	7.350b
Germination percentage (%)	71.00a	71.00a
Mean germination time (days)	5.50a	4.07b
Germination speed index	3.63b	6.92a
Emergence percentage (%)	75.00b	90.00a
Mean emergence time (days)	8.20a	5.44b
Emergence speed index	1.92b	3.52a
Height of seedlings (cm)	3.40a	3.75a
Root length of seedlings (cm)	5.125b	8.450a
Number of leaves of the seedlings	2.000a	2.000a

*Letters compare the parameters between green and brown seeds (DAT). Same letters do not differ by Tukey's test at 5%.

According to Marcos Filho (2005) seed health reflects a set of characteristics that determines the potential for rapid and uniform emergence of seedlings. The author also reports that the proportion of healthy seeds increases with maturity, reaching the maximum value with the highest accumulation of dry matter. However, in this study, there was no significant difference in the dry matter between green and brown seeds of *A. niopoides,* even when the green seeds had a higher water content.

Green seeds began germination 48 hours after the experiment, reaching 71% of germinated seeds, and the brown seeds began germination after 24 hours. In the end, there was no significant difference in relation to the percentage of germination. However, brown seeds had a lower mean germination time and a higher germination speed index (Table 1). Considering the growth, there was a higher percentage of emergence and emergence speed index (as well as a shorter emergence time for seedlings) from brown seeds (Table 1).

The highest root length observed in the seedlings from brown seeds may be associated with the lower mean seedling emergence time, which resulted in superior root growth of these seedlings in relation to those obtained from green seeds. According to França Neto, Krzyzanowski, and Henning (2012), seedlings that emerge earlier have a competitive advantage because they take better advantage of environmental resources.

Germination begins with the imbibition phase and ends with the protrusion of the embryonic axis, usually the radicle. The duration of each imbibition phase depends to some extent on the properties inherent to the seed and environmental conditions. The absorption of water by the seed, in step 1, depends on the matric component. The force driving the water absorption depends on the water potential gradient and the initial content of seed water Bewley et al. (2013). This influenced the mean germination time in *A. niopoides,* being lower in brown seeds with lower water content.

Souza and Marcos Filho (2001) associate the color of the coat as a characteristic of the seed that also influences the water absorption, with the darkest coat of the seed being correlated with the slower rate of imbibition in several species of Leguminosae. Bewley et al. (2013) also report that quiescent seeds have water content between 5 and 15%. Gonzales, Paula, and Valeri (2009) found an GSI of 1.05 to 8.47 in the batch of *Albizia hassleri,* identical to *A. niopoides*, and seed water content ranging from 9.2 to 15.3%. These are results similar to those observed in the present study.

Albizia niopoides seeds without treatment to break their dormancy reached 80% germination with an average time of six days (Wielewicki, Leonhardt, Schlindwein, & Medeiros, 2006). Fowler, Carpanezzi, and Zuffellato-Ribas (2006) reported the presence of cutaneous numbness in *A. niopoides* seeds, which when treated with sulfuric acid may have a germination rate above 80%. This percentage was also obtained by Kissmann et al. (2009) when treating the seeds with sulfuric acid for 20 min.

Considering the process of seed development, the last phase is characterized by the intensification of the desiccation of seeds, preceded by the phase of accumulation of reserves and progressive increase of dry matter (Ferreira & Borghetti, 2004; Marcos Filho, 2005). Thus, the green and brown seeds of *A.niopoides* were at distinct stages of development, with the brown seeds being suitable for dispersion. However, green seeds still presented high water content, but with the accumulation of material similar to those of brown seeds. With this, there was no loss in germination percentage and seedling growth, in relation to shoot height and leaf emission from green seeds. Brown seeds showed higher germination percentage of seeds of *Clitoria fairchildiana* Haward (Alves et al., 2013) and seeds of *Caesalpinia echinata* Lam. (Aguiar et al., 2007). Moreover, brown seeds of *C. fairchildiana* showed a higher rate of germination and produced seedlings that had larger root length. But there were no significant differences in relation to the length of the shoot (Alves et al., 2013), which is a result similar to that of *A. niopoides.*

The shortest emergence time of seedlings from brown seeds of *A. niopoides* was associated with the higher percentage and emergence speed index and represented a competitive advantage in the environment. This is because, according to França Neto et al. (2012), seedlings that emerge earlier have better use of water, light and nutrients. Carvalho (2009) reports that the emergence of *A. niopoides* lasts of 10 to 40 days for seeds which have not undergone a break the dormancy. However, in this study, the mean emergence time was lower than that described by the author.

Seedlings from green and brown seeds showed no significant difference, so the growth parameters were analyzed considering only the DAT. A significant increase in shoot height (H) and root length (LR) was observed at 90 and 180 days after transplanting (DAT). However, there was no significant difference in the number of leaves at 90 and 180 DAT (Table 2).

Table 2. Growth parameters of *Albizia niopoides* (Bentham) Burkart (Fabaceae) in days after transplanting (DAT), being shoot height (H), number of leaves (NF), root length (RL), shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM).

Parameters	H (cm)	NF	RL (cm)	SDM (g)	RDM (g)	TDM (g)
60 DAT	6.87d*	6.00a	10.62b	0.054c	0.019b	0,074b
90 DAT	18.83b	12.33b	19.67b	1.149b	0.651b	1,799b
180 DAT	38.17a	12.67a	36.83a	2,536a	2,536[a]	5.023a

*Uppercase letters compare the parameters of each DAT. Same letters do not differ by Tukey's test at 5%.

In relation to matter gain over time, higher values of shoot dry matter (SDM), root fresh matter (RFM) and root dry matter (RDM) were observed at 180 DAT, as well as higher total dry matter in the final collection (Table 2). There was no significant difference between 60 and 90 DAT, considering RFM, RDM and TDM.

At 60 and 90 DAT, there was a higher increase in shoot dry matter compared to the total dry matter, reducing significantly at 180 DAT. Greater investment in root dry matter was observed at 180 DAT, which could be associated with significantly higher RDM/SDM ratio, and RDM/TDM ratio, and SDM/TDM ratio reduction at 180 DAT (Figure 2A).

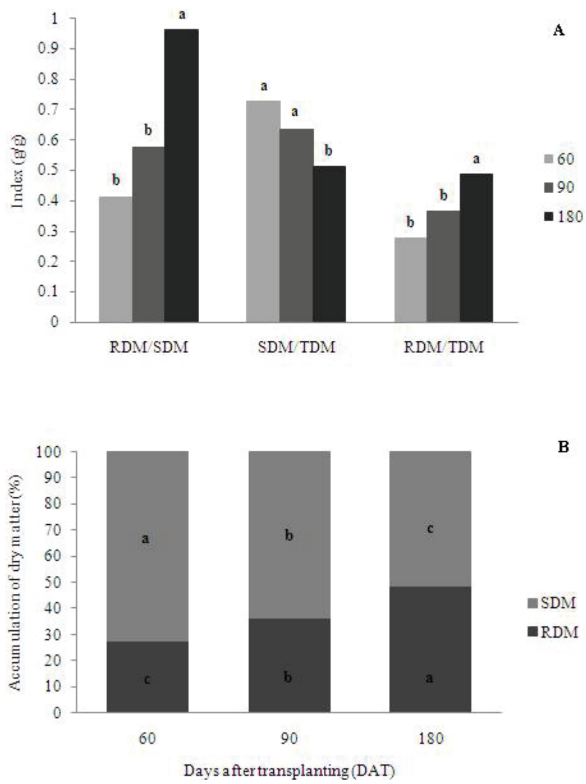

Figure 2. (A) Root dry matter/shoot dry matter ratio (RDM/SDM), shoot dry matter/total dry matter ratio (SDM/TDM), root dry matter/total dry matter ratio (RDM/TDM) and (B) Accumulation of shoot dry matter (SDM) and root dry matter (RDM) in *Albizia niopoides* plants grown in greenhouse and analyzed at 60, 90, and 180 days after transplanting (DAT).

Still, considering the growth parameters, the SDM indicates the hardiness of seedlings, and a higher value is indicative of greater lignification and more success in establishment despite adverse conditions (Gomes & Paiva, 2006). For *A. niopoides*, the highest value of SDM was found at 180 DAT. During this period, higher MSR and TDM rates were verified, which guarantee higher seed quality and increased possibility of success in field establishment. Related to these parameters, the H/SDM ratio indicates the survival potential of seedlings in the field (Gomes et al., 2002) and the lower value suggests higher lignification, which can guarantee greater success in the establishment.

The greatest investment in total dry matter, root dry matter, and root length at 180 DAT also suggested higher quality of the seedlings in this period, as well as the higher number of leaves indicating greater potential of photosynthesis and production of photoassimilates, which would be translocated to the root system, providing greater root growth. This is verified by the higher RDM/SDM and RDM/TDM ratios at 180 DAT.

Clifton-Cardoso, Mielke, Melo, and Querino (2008) found lower values for H, TDM, and NF in *Dimorphandra jorgei* at 112 days, grown in sandy soil and full sunlight. Lower values for SDM, RDM, and TDM were also obtained for *S. virgata* at 150 days (Delarmelina et al., 2014).

The highest dry matter investment was significantly higher in the shoot at 60 and 90 DAT, and at 180 DAT there was no difference in relation to dry matter accumulation between shoots and roots (Figure 2B). At each evaluation period, there was a reduction in dry matter accumulation in the shoot. Also, a significant increase in the root dry matter increment was observed at 180 DAT (Figure 2B).

The stem diameter (SD), stem height/diameter (H/SD), and Dickson quality index (DQI) were evaluated at 180 DAT, and resulted in a mean SD of 3.93 mm, H/SD of 9.83, while the DQI in this period was 0.47.

The stem diameter (SD) is one of the most suitable parameters for assessing the survivability of the field seedlings (Delarmelina et al., 2014), which was verified from SD 2.41 to 4.59 mm in *Sesbania virgata* plants (Cav.) Pers., at 150 days after sowing. Gonçalves, Santarelli, Moraes Neto, and Manara (2000) indicate that the SD must be between 5 and 10 mm and according to the observed in this study for *A. niopoides*, the plants at 180 DAT would still not have adequate SD value. However, considering height/stem diameter ratio (H/SD), the value should be less than 10.0 (Delarmelina et al., 2014), which was found in this study for *A. niopoides.* Abreu, Leles, Melo, Ferreira, and Monteiro (2015) found a value of H/SD equal to 7.0 for *Enterolobium contortisiliquum* at 150 days. These authors also report that the H/SD ratio is one of the most used parameters to evaluate the quality of forest seedlings, since it ensures greater resistance to dry periods and greater attachment to the soil.

The Dickson quality index is a good indicator of the seedling quality, since the robustness and the balance of biomass distribution in the seedling are considered for calculation (Fonseca, Valéri, Miglioranza, Fonseca, & Couto, 2002). The value obtained for *A. niopoides* at 180 DAT was higher than that 0.20, which considered as the standard minimum DQI value.

The occurrence of bacterial nodules in the roots was not observed until 180 DAT.

Conclusion

Brown seeds of *A. niopoides* had higher %G and GSI, while seedlings from brown seeds presented higher percentage and emergence index. Thus, brown seeds showed higher vigor in germination and emergence, which may promote greater success in the initial establishment of seedlings.

At 180 DAT, *A. niopoides* showed higher H, LR, SDM, RDM, and TDM, in addition to the adequate values of DQI and relative H/SD, indicating that these plants would be successful in the field.

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