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Water absorption and method improvement concerning electrical conductivity testing of *Acacia mangium* (Fabaceae) seeds

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Abstract: *Acacia* is an important forest species of rapid growth whose seeds have tegument dormancy. In this work it was intended to characterize water absorption pattern after seed dormancy break, and to determine the amount of water, container size and the need of breaking the tegument dormancy, as to perform electrical conductivity test in small and large seeds of *Acacia mangium* (Fabaceae). The seeds were collected from 10, 8 and 6 years old trees established in poor yielding-capacity soils on savannah areas of Roraima, Brazil; seeds were classified in six lots concerning to seed size and tree age. Germination tests (50 seeds and four replications per lot) were carried out on germitest® paper maintained on gerbox at 25 °C. Imbibition was verified by seed weighing at different times (0, 2, 5, 8, 12, 16, 24, 36, 48, 60, 72, 84, 96 and 120 hours). The electrical conductivity test consisted of three experiments, distinguished by the amount of water used and by the container size in which seeds were immersed. Seeds of *A. mangium* coming from 10 years old trees presented increased germination percent and germination speed than seeds of six-year old trees. Small seeds presented increased in electrical conductivity and water absorption until 120 hours when compared to large seeds. The immersion of seeds of *A. mangium* in 40 mL of distilled water into 180 mL plastic containers, after dormancy break, it is indicated for the determination of electrical conductivity test. The ratio of electrolytes by seed mass, after 24 hours of immersion in water, turns electrical conductivity test more accurate concerning *A. mangium* seeds. Rev. Biol. Trop. 64 (4): 1651-1660. Epub 2016 December 01.

Key words: *Acacia mangium*, physiological quality, seeds vigor.

In the latest decades, the forest-covered area of the terrestrial globe has been devastated in consequence of the irrational logging (Rodrigues, Kohl, Pedrinho, Arias, & Favero, 2008). According to Ibama (2015), it is estimated that 15 % of the Amazon rainforest has already been deforested. According to Rosa, Martins and Silva (2006), this situation, in simplistic reasoning, shows the need of forest production with fast-growing species, since the deficit in annual balance occurs between reposition and wood consumption.

The genus *Acacia* can be an alternative, since it comprehends about 1200 species, most of them being fast-growing pioneers, adaptable to most varied types of soils and occurring naturally on several continents (Rodrigues et al., 2008). Dormancy causes unevenness among the nursery-produced seedlings, and longer time of exposition to adverse conditions, like the action of pests and deterioration. Although exotic, *Acacia* can recover degraded ecosystems, especially those with stony ground areas and with shallow soils or formed by sand dunes (Balieiro, Dias, Franco, Campello, & Faria, 2004).

In the state of Roraima, Brazil, *Acacia mangium* Willd. (Fabaceae) is the forest species with largest planted area, occupying around 30 000 ha on savannah areas. However, in Amazon rainforest, commercial forest plantings are still few, due mainly to reduce scientific knowledge about the performance of native forest and exotic species in the region, in addition to the poor availability of good quality seeds (Souza, Rossi, Azevedo, & Lima, 2004).

In forestry practice, it is desirable to obtain homogeneity, both in size and time in the production of seedlings of forest species, especially those presenting seeds with a high degree of dormancy, a shared characteristic among many forest species. Forest research concerning methodologies in seed analyses are highly important for seed technology, as they provide information related to the physiological quality of the lot aiming the preservation and utilization of seedlings for different purposes (Alves, Bruno, Oliveira, Alves, & Paula, 2005; Cherobini, Muniz, & Blume, 2008).

In spite of the intensity of research related to seed size and its influence over the physiological quality in several species, information among forest species is not frequent. Seed classification by size or by weight for the determination of seed quality, using germination and vigor tests, is utilized to find the ideal class, and then, to produce several plant species (Torres, 1994). Due to difficulties found concerning germination among forest species, alternative tests, like water imbibition curve and electrical conductivity tests under controlled conditions are being applied in many laboratories with the objective of defining seed vigor and viability. The fastness in obtaining reliable results is one of the main aspects considered in the evaluation of seed quality, for it allows agility in decision making, enables its use in wider scales, decreasing the risks and costs in operations like harvest, processing, storage and commercialization (Barbieri, Menezes, Conceição, & Tunes, 2012; Hilst, Dias, Alvarenga, & Souza, 2012; Matos, Borges, & Silva, 2015).

In the electrical conductivity test, which allows vigor comparisons between different samples of seeds, the values obtained are due to the disorganization of cell membrane and the decrease of the respiratory and biosynthetic capacity (Coutinho, Silva-Mann, Vieira, Machado, & Machado, 2007). Due to those two processes, electrolytes are released in imbibition water, the intensity of the electric current of those electrolytes being measured even by total or individual method (Vieira & Krzyzanowski, 1999).

The results of the conductivity tests can be affected by water quality, amount of tested seeds, temperature, imbibition time and degree of moisture (Bewley, Bradford, Hilhorst, & Nonogaki, 2013). Nevertheless, some authors have pointed out the importance of the development/or adjustment of these fast tests for the different forest species, since the efficiency of procedures in the evaluation of physiological potential will depend on them (Lopes, Silva, & Vieira, 2013; Araldi & Coelho, 2015). This way, the objective of this research was to evaluate the potential use of the best water absorption pattern, container size and the need of breaking the tegument dormancy, for the application of the electrical conductivity test in small and large seeds of *Acacia mangium,* coming from commercial plantings of different ages, established in low yielding capacity soils on savannah areas of Roraima.

MATERIALS AND METHODS

The seeds were collected in January of 2011 from trees localized in Serra da Lua region (2° 33’ 36’’ N - 60° 19’ 12’’ W) in the municipality of Bonfim, in different plots planted in 2001, 2003 and 2005 (plants 10, 8, and 6 years old when the seeds were collected, respectively). The seeds of each planting year were classified with square 1.8 mm width holes, into small and large seeds, making up, thus, 6 lots (3 lots of large seeds and 3 lots of small seeds), each of them having its mass of 1 000 seeds determined according to Brasil (2009).

Water content in seeds was determined by utilizing two replications of 1±0.003 g of seeds, previously weighted and oven-dried at 105±3 °C for 24 hours as to obtain seed dry mass. Calculation of moisture degree was based on fresh mass of seeds (Brasil, 2009). Obtained average water content of 6.4 % was utilized to convert the 1 000-seed mass to 11 % of moisture. Germination test was carried out with four 50-seed replications in plastic boxes (gerbox®) on seed germination paper (germitest®) moistened with distilled water 2.5 times the paper weight and maintained in germination chambers at 25±2 °C (ELETROlab, mod 006M) under constant light of 0.42 Klux and humidity of 78 %. The test consisted of treatments without and with seed dormancy break, which was obtained through seed immersion for 60 seconds in water heated at 100 °C (Smiderle, Mourão Junior, & Sousa 2005).

Germination test was performed by daily counting to the fourteenth day, considering the number of seeds that emitted a radicle longer than 2 mm (Labouriau, 1983). With data obtained in the germination test the average germination time was calculated – Tm (Edmond & Drapala, 1965) as well as the germination velocity index – VG.

Imbibition of the seeds was carried out with four replications of 50 seeds for each lot, firstly being weighted and submitted to the dormancy break, according to Smiderle, Mourão Junior, and Sousa (2005), and afterwards, arranged between germitest® paper sheets moistened with distilled water (2.5 times the paper weight) and placed into gerbox® boxes, maintained in BOD chamber at the constant temperature of 25 °C.

Imbibition process was conducted with periodic weighting (0, 2, 5, 8, 12, 16, 24, 36, 48, 60, 72, 84, 96 and 120 hours), until at least a seed of each replicate emitted a radicle. After the last weighing, the moisture degree of seeds was determined (Brasil, 2009). For each weighing the imbibition percentage of the seeds (% E) was measured by utilizing the formula:

$$\%E = \frac{(Mf - Mi)}{Mi} x100$$

Where: M*f* = mass after imbibition; and M*i*= initial mass of the seed. Data obtained from imbibition test were submitted to regression analysis at 5 % of probability in a completely randomized design in a 6x14 factorial scheme (six lots of seeds and 14 periods of weighing).

Leaching pattern of the exudates was obtained for seeds of all six lots, without and with dormancy break (Smiderle et al., 2005), using four replications of 50 seeds previously weighted on an analytical balance with precision of 0.001 g. The electrical conductivity test consisted of three experiments. In experiment I, 75 mL of distilled water were utilized in plastic cups (8 cm high, 7 cm in upper diameter and 4 cm in base diameter) with a capacity of 180 mL. In experiment II, 40 mL of distilled water in plastic cups with a capacity of 180 mL were utilized, and in Experiment III, 40 mL of distilled water in plastic cups (4 cm height, 4.5 cm in upper diameter and 3.5 cm in base diameter) with a capacity of 50 mL were utilized. The plastic containers containing distilled water were maintained in germination chamber-BOD at 25 °C for 24 hours. After the period, the imbibition solution was stirred gently and the conductivity reading was carried out on bench conductivity meter and the results being divided by the respective initial mass of the seed and by the mass after 24 hours of immersion in the solution. The values were expressed in µS/cm/g of seed.

Considering the three experiments, the electrical conductivity test was conducted in a completely randomized design in a 3x2x2 factorial scheme (3 years of planting; 2 seed sizes, with and without overcoming of tegument dormancy). The values obtained from electrolyte leaching were analyzed with statistical software Sisvar (Ferreira, 2011) and the means compared by Tukey test at 5 % of probability.

RESULTS

The average results concerning 1 000 seed mass obtained for the six lots are shown in table 1, where the average mass of small seeds was 7.54 g, for large seeds 9.37 g, while the lot of seeds coming from trees six years old presented less mass (7.96 g).

The average values of germination percentage for seeds without dormancy break were

TABLE 1
Means of 1 000 seed mass (g), germination (G, %), hard seeds (D, %), average germination time (TMG, days) and germination speed (VG, index) of *Acacia mangium* small and large seeds, without and with tegument dormancy break, coming from trees of different ages. Boa Vista, Roraima

Age	Size	Mass 1000 seeds	Without seed dormancy break				With seed dormancy break			
			G	D	TMG	VG	G	D	TMG	VG
10	Small	7.834	2	98	6	0.09	93 a	0	7 ab	6.99 a
	Large	9.621	2	96	8	0.23	87 ab	0	8 bc	6.18 b
8	Small	7.601	2	94	5	0.30	91 a	0	7 a	7.44 a
	Large	9.743	6	90	6	0.89	82 b	0	8 bc	5.73 bc
6	Small	7.166	0	98	-	0.00	74 c	0	8 bc	5.21 cd
	Large	8.759	0	98	-	0.00	72 b	0	8 c	4.71 d
Means of the tree-aging										
10	-	8.727	2	97	7	0.16	90 a	0	7 a	6.58 a
8	-	8.672	4	92	6	0.59	86 a	0	7 a	6.58 a
6	-	7.963	0	98	-	0.00	73 b	0	8 b	4.96 b
Means of the seed size										
-	Small	7.534	1	97	6	0.13	85 a	0	7 a	6.54 a
-	Large	9.374	3	95	7	0.37	81 b	0	8 b	5.53 b

* In the column, means followed by the same letter do not differ from one another by the Tukey test (P>0.05).

up to 6 %, due to a great part of the seeds not having imbibed water, as can be observed in the average values of percentage of remaining hard seeds up to 14 days after sowing (Table 1). For seeds subjected to dormancy break, there were no hard seeds and the average percentage of germination of the six lots ranged from 72 % to 93 % (Table 1).

There was no statistical significance in the interaction year and size for the seeds that had undergone the scarification process. In table 1 higher means of germination percentage and germination speed index were observed for the seeds coming from trees 10 and 8 years old and lower for those coming from six year old trees. The opposite was found for the average time of germination values, where lower values were obtained for seeds from trees 8 and 10 years old and greater for the ones obtained from six years old trees. Concerning seed size, those classified as small germinated more, in less time and presented higher germination speed index (Table 1) in relation to the large seeds, by the Tukey test (P <0.05).

Water absorption curves obtained from large and small seeds of *A. mangium* are observed in figure 1, where for each year, small seeds tended to result into higher immersion percent in relation to large seeds until 120 hours. Radicle emission was observed since 72 h and considering the 120-hour period, all the replications presented at least one germinated seed when the experiment was ended. However, the change between phases of the imbibition process was not visible due to, possibly, the lack of uniformity in seed imbibition and may be due to different maturation stages. The subtle presence of phase II in the range between 60 and 100 hours was then observed (Fig. 2).

Means of seed electrical conductivity in the six lots after 24 hours of immersion concerning three experiments without dormancy break and the means for the seeds with dormancy break are presented in table 2.

Comparing electrical conductivity values of the lots of same year (Table 2), for each experiment, it was found that the lowest values were obtained for the seeds classified as small relative to large seeds. However, in experiment III, this difference was not observed and average electrical conductivity was lower for large seeds when dormancy break was not held.

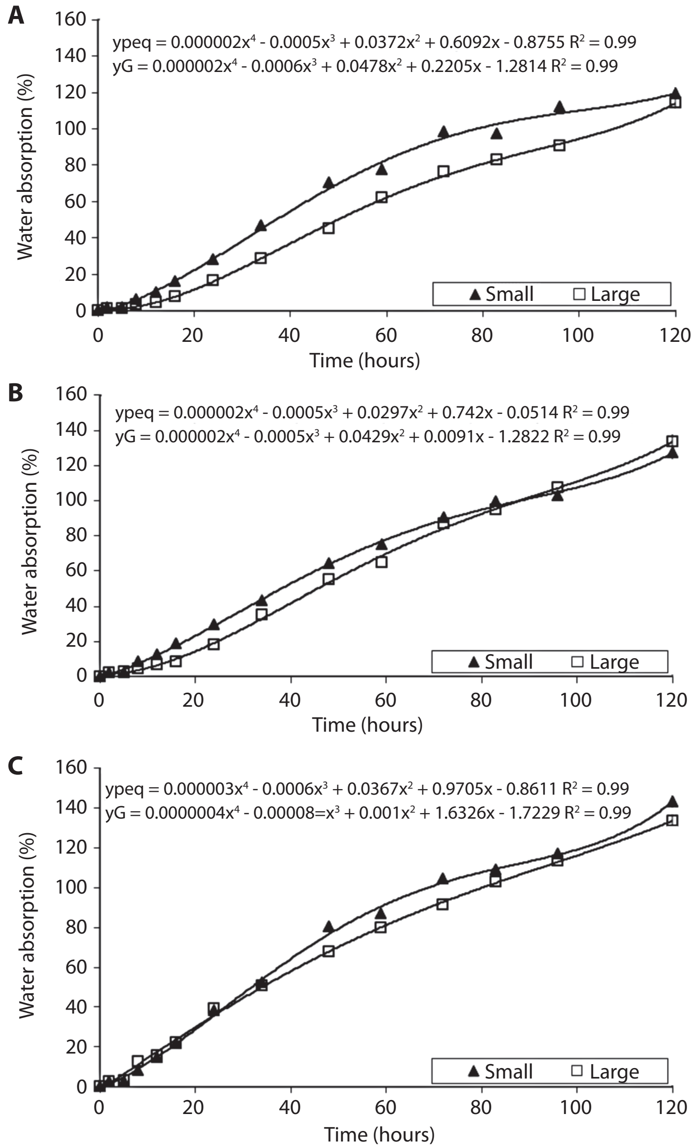

Fig. 1. Water absorption curves in small and large seeds of *A. mangium,* with tegument dormancy, coming from trees of ages of 10 (**A**), 8 (**B**) and 6 years (**C**). Boa Vista, Roraima.

However, with dormancy break of small seeds, in all three experiments they presented higher values of electrical conductivity (EC), except for seeds of trees 10 years old in experiment I. This also occurred with the final moisture content of the seeds.

The seeds which were given no treatment to break dormancy, presented electrical conductivity values inferior to 59 µS/cm/g of seed, due to the low percent of seeds which imbibed water when there was no dormancy break (Table 2). Thus, in table 2 the values of the electrical conductivity of *A. mangium* seeds with tegument dormancy break were up to 287.48 µS/cm/g of seed.

Due to the fact that seeds present tegument dormancy, the increase in mass was 6 % after immersion in water for 24 hours for the seeds

TABLE 2

Means of initial mass and after 24 hours' immersion (g), degree of moisture (U, %), electrical conductivity (CE, µS/cm/g) and electrical conductivity with the mass after 24 hours of immersion (CE (24h), µS/cm/g) obtained from small and large seeds of *A. mangium,* without and with tegument dormancy break, coming from tree of different ages. Experiments I, II, III. Boa Vista, Roraima, 2012

Experiment	Age	Size	Initial mass	Mass immersion	U%	CE		CE (24h)	
Without seed dormancy break									
I	10	Small	0.3648	0.3830	12.3	23.018	a	21.921	a
		Large	0.4550	0.4790	13.1	27.673	a	26.325	a
	8	Small	0.3460	0.3670	13.8	29.222	a	27.328	a
		Large	0.4483	0.4808	13.1	35.220	a	33.043	a
	6	Small	0.3453	0.3563	10.2	29.589	a	28.499	a
		Large	0.4110	0.4333	12.8	30.796	a	29.193	a
		mean	**0.3950**	**0.4165**	**12.6**	**29.253**		**27.718**	
II	10	Small	0.3635	0.3760	11.1	28.919	a	27.945	a
		Large	0.4555	0.4875	15.3	36.924	ab	34.152	ab
	8	Small	0.3483	0.3618	11.1	37.705	ab	36.264	ab
		Large	0.4470	0.4883	14.7	55.181	d	50.075	d
	6	Small	0.3353	0.3520	12.3	44.508	bc	42.346	bc
		Large	0.4128	0.4475	15.9	55.820	cd	51.856	cd
		mean	**0.3937**	**0.4188**	**13.4**	**43.176**		**40.440**	
III	10	Small	0.3568	0.3845	15.3	43.187	ab	40.020	a
		Large	0.4515	0.4788	13.6	37.949	a	36.197	a
	8	Small	0.3488	0.3783	13.6	52.619	ab	48.567	ab
		Large	0.4475	0.4750	12.8	41.361	a	39.182	a
	6	Small	0.3353	0.3595	14.7	58.841	b	54.729	b
		Large	0.4120	0.4370	14.8	46.481	ab	43.830	ab
		mean	**0.3920**	**0.4188**	**14.1**	**46.740**		**43.754**	
With seed dormancy break									
I	10	Small	0.3670	0.7788	59.1	125.759	a	59.248	a
		Large	0.4545	0.9858	59.2	135.806	a	62.619	a
	8	Small	0.3475	0.7855	60.8	140.583	a	62.170	a
		Large	0.4483	0.9600	58.5	123.144	a	57.497	a
	6	Small	0.3428	0.7603	59.5	142.664	a	64.278	a
		Large	0.4115	0.8838	59.3	136.572	a	63.589	a
		mean	**0.3953**	**0.8590**	**59.4**	**134.088**		**61.567**	
II	10	Small	0.3650	0.8098	60.9	248.367	abc	111.932	ab
		Large	0.4540	0.9753	60.2	221.941	abc	103.210	a
	8	Small	0.3473	0.7925	61.6	249.729	bc	109.434	ab
		Large	0.4465	0.9583	58.9	217.113	a	101.178	a
	6	Small	0.3330	0.7418	61.4	264.854	c	118.908	b
		Large	0.4130	0.8905	59.0	236.573	abc	109.669	ab
		mean	**0.3931**	**0.8613**	**60.3**	**239.763**		**109.055**	
III	10	Small	0.3583	0.8170	61.7	266.369	bc	116.787	bc
		Large	0.4515	0.9898	59.3	227.593	a	103.756	a
	8	Small	0.3485	0.7963	61.4	237.510	ab	103.942	a
		Large	0.4478	0.9735	59.1	224.751	a	103.213	a
	6	Small	0.3355	0.7955	62.3	287.482	c	121.209	c
		Large	0.4108	0.8963	58.6	234.194	ab	107.404	ab
		mean	**0.3920**	**0.8780**	**60.4**	**246.316**		**109.385**	

I - 75 mL of water in 180 mL container; **II** - 40 mL of water in 180 mL glasses; and **III** - 40 mL of water in 50 mL glasses.
* In each experiment, means followed by the same letter in the column do not differ from one another by the Tukey test ($P<0.05$).

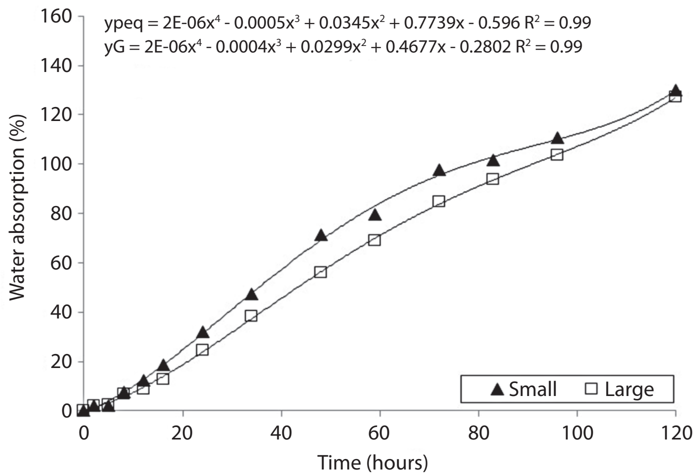

Fig. 2. Water absorption curves obtained for the average values of the three lots of small seeds and three lots of large seeds of *A. mangium,* with tegument dormancy break. Boa Vista, Roraima.

whose dormancy was not broken (Table 2). However, the seeds which were given dormancy break treatment showed an average increase of 123 % (Table 2). This increase in the seed mass was due to water imbibition during the immersion period, which resulted in reduced quantity of free water in plastic cups. Analizing planting ages, it was found that there was no influence of tree age on average values of electrical conductivity of *A. mangium* seeds.

Comparing all three experiments in which seeds were submitted to dormancy break (Table 2), it was found that with 53 % reduction of water volume, from experiment I (75 mL) to experiment II (40 mL), there was an increase in electrical conductivity value of 77 % and by reducing the container size (experiment III), utilizing 40 mL of distilled water, the conductivity value kept a close relation as in experiment II. However, the electrical conductivity values obtained in experiment III do not follow the same pattern of the results obtained in the germination test (Table 1), observing this way the influence of container size on the results of electrical conductivity.

The average increases of wet mass verified in the experiments were 106.1 % in seeds without dormancy break and 220.4 % in seeds with dormancy break, reflecting on an average of 207 %. Considering this mass for the EC calculation resulted, respectively, into 6.1 % and 54.8 % of reduction of EC values with and without dormancy break.

DISCUSSION

Germination percentages with similar ranges as those obtained in this work, were also reported by Smiderle, Mourão Junior and Sousa (2005) with pre-germination treatments of *Acacia* seeds: no dormancy break seeds showed 3 % germination, and dormancy break seeds with values greater than 80 % germination.

Seeds classified as small presented a tendency of imbibing more than the large ones, indicating that larger seeds are slower to absorb water relative to smaller ones. The need and importance of standardizing the seeds by size in the formation of lots to obtain more adjusted results in tests that determine the physiological quality and, especially, vigor in seeds of *A. mangium,* become evidenced. Oliveira and Bosco (2013) found that vigor in *Copernicia hospita* Mart. (Arecaceae) seeds, measured by the average emergency time was directly proportional to the size, being smaller in smaller seeds. Pagliarini, Nasser, Nasser, Cavichioli and Castilho (2014) found that seeds classified as medium or large are best for production of courbaril seedlings (*Hymenaea courbaril* L., Fabaceae).

Duarte, Carneiro, Silva and Guimarães (2010), working with seeds of *Dyckia goehringii* Gross & Rauh (Bromeliaceae), while characterizing the imbibition curve at different temperatures, also verified the absence of the three-phase pattern in the imbibition of these seeds till 138 hours. The same authors also observed that small seeds of this species tended to absorb more water than large seeds. The non-identification of the three-phase pattern was also verified by Neves, Brandão Junior, Silva, Brandão and Sales (2010) among seeds of *Joannesia princeps* Vell. (Euphorbiaceae) which seed coat acted negatively on water absorption. The biochemical and physiological mechanisms of the germination process metabolism begun with germination extending into the primary root emission and varies according to the level of seed hydration. It shows, thus, the importance of monitoring the absorption of water by the seed. Comparing the three experiments without dormancy break, it was observed that with the 53 % reduction of the volume of distilled water from experiment I to experiment II, there was a 45 % increase of electrical conductivity value. However, keeping the volume of water in 40 mL and changing the container size (Experiment II to experiment III), increase was also observed in electrical conductivity of 57 % in relation to experiment I.

Comparing the electrical conductivity values obtained from seeds coming from trees of the same planting year, for each experiment, it can be seen that small seeds showed higher electrical conductivity than the seeds classified as large. Malta, Pereira and Chagas (2005), in work conducted with *Coffea arabica* L. (Rubiaceae), also found that small seeds presented greater values of electrical conductivity. This occurs because small seeds have larger specific area than large seeds, allowing greater release of electrolytes in 24 hours due to more rapid imbibition as viewed in this work.

The electrical conductivity value depends on the seed mass and on the amount of water in the container. Determination of electrical conductivity in μS/cm/g of seed utilizing the initial mass of the seeds, resulted into electrical conductivity values far from the results found in the germination test. However using the final mass of seeds obtained after 24 hours of immersion in water, better adjustments to data obtained in the germination test were attained making the adoption possible concerning *A. mangium* seeds.

Observing germination percentage and germination speed of seeds with dormancy break, it can be noted that lots with greatest vigor also presented the highest electrical conductivity values, possibly due to greatest water absorption speed or smallest seed mass utilized. This aspect was also verified by Oliveira and Bosco (2013) working with *Copernicia hospita*, where they obtained shorter time to emergency with small seeds.

It is known that the improvement of the methodology for electrical conductivity test in seeds should be carried out with strong scientific background, seeking to conform it to the conditions intrinsic to the species. The observed results indicated that the electrical conductivity test was efficient to assess the feasibility of *A. mangium* seeds, providing important information for decision making about the best use of seed lots according to vigor.

Seeds from trees 10 years old present a higher germination percent and germination speed than seeds of six-year old trees. Small seeds of *Acacia mangium* present greater electrical conductivity and percentage of water imbibition than large seeds, to 120 hours.

The immersion of *A. mangium* seeds into 40 mL of distilled water in plastic containers of 180 mL, is recommended for the determination of the electrical conductivity, after dormancy break. The ratio of electrolytes by seed mass after 24 hours of immersion in water, turns electrical conductivity test more accurate concerning *A. mangium* seeds.

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RESUMEN

Absorción de agua y optimización de métodos para medir la conductividad eléctrica en semillas de ***Acacia mangium*** **(Fabaceae).** *Acacia* es una importante especie forestal de rápido crecimiento cuyas semillas presentan dormancia del tegumento. En este trabajo se caracterizó el patrón de absorción de agua después de la dormancia y se estableció la cantidad de agua, el tamaño del recipiente y la necesidad de ruptura del tegumento para poder medir la conductividad eléctrica en semillas pequeñas y grandes de *Acacia mangium* (Fabaceae). Las semillas fueron recolectadas de árboles de 6, 8 y 10 años, clasificadas en grandes o pequeñas y agrupadas en seis grupos. Para la prueba de germinación fueron utilizados cuatro repeticiones de 50 semillas de cada grupo, en papel germitest® a 25 °C. La imbibición se verificó con pesajes en los tiempos 0, 2, 5, 8, 12, 16, 24, 36, 48, 60, 72, 84, 96 y 120 horas con semillas colocadas en papel. La prueba de conductividad eléctrica se realizó en tres experimentos diferenciados por la cantidad de agua utilizada y el tamaño del recipiente de inmersión de las semillas. Las semillas de árboles de 10 años de edad tienen un porcentaje de germinación más alto y mayor velocidad de germinación que semillas de árboles de seis años. Las semillas pequeñas tienen una mayor conductividad eléctrica y mayor porcentaje de absorción de agua en comparación con las semillas grandes, hasta 120 horas. La inmersión de semillas en 40 mL de agua destilada en recipientes plásticos de 180 mL, después de la dormancia, esta indicada para la determinación de la conductividad eléctrica. La lectura de electrolitos en semillas, después de 24 horas de inmersión en agua, hace más precisa la prueba de conductividad eléctrica de semillas de *A. mangium*.

Palabras clave: *Acacia mangium* Willd., calidad fisiológica, vigor de semillas.

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