

EFFECTS OF PRE-GERMINATION TREATMENTS, SALT AND WATER STRESSES ON GERMINATION OF *ACACIA EHRENBURGIANA* HAYNE AND *ACACIA SEYAL* DEL. (MIMOSOIDEAE): TWO ALGERIAN NATIVE SPECIES

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Abstract. *Acacia ehrenbergiana* Hayne and *Acacia seyal* Del. are two desert trees of the Algerian Sahara that for a long time were confused. These two species present high potentials for desert areas rehabilitation therefore for successful seed germination and establishment three pre-germination treatments (manual scarification, boiling water and concentrated sulphuric acid) were used to overcome seeds dormancy. Once the optimal conditions are determined, we examined the effects of two abiotic stresses (salinity and water deficiency) on their seeds germination using eight levels of salinity (0, 50, 100, 150, 200, 250, 300 and 350mM of NaCl) and six concentrations of PEG₆₀₀₀ (0, -2, -4, -6, -8 and -10 bars) on *Acacia ehrenbergiana* Hayne and *Acacia seyal* Del. Germination rate and mean germination time were calculated and data were subjected to analysis of variance (ANOVA) followed by Newman-Keuls test. Our results show that manual scarification and sulphuric acid had significant effects on the seeds germination of *Acacia ehrenbergiana* Hayne meanwhile, only sulphuric acid enhanced *Acacia seyal* Del. seeds germination. Under salt and water stresses, the germination rate and mean germination time of *Acacia ehrenbergiana* Hayne were less affected than those of *Acacia seyal* Del. Therefore manual scarification and sulphuric acid treatments could be applied and adopted at laboratory level or even at nurseries to raise plants germination and plantations establishment for desert areas rehabilitation. Thus, *Acacia ehrenbergiana* Hayne seems to be more suitable for massive propagation as it demonstrates resilience when facing harsh abiotic stresses (salt and water stresses).

Keywords: *Acacia* trees, seeds, germination, coat dormancy, abiotic stress, desert

Introduction

Native acacia trees are frequent, widespread and emblematic species that grow in Algerian desert areas which cover 2/3 of the country surface. They are represented by six species; five of them were recently transferred from the genus *Acacia* to the genus *Vachellia*: *Acacia tortilis* (Forssk.) Hayne subsp. *raddiana* (Savi) Brenan., *Acacia nilotica* subsp. *adstringens* (Schumacher & Thonn.) Roberty, *Acacia nilotica* subsp. *tomentosa* (Benth.) Brenan, *Acacia ehrenbergiana* Hayne, *Acacia seyal* Del. and one species: *Acacia laeta* R.Br. ex Benth. was transferred to the genus *Senegalia* (Ross, 1979; Kyalangalilwa, 2013).

These species play fundamental roles in desert areas, allowing sand's fixation, helping the water infiltration and improving the redistribution of nutritive elements in the soil. Moreover, their ability to develop dual symbiosis with *Rhizobia* and endomycorrhizal fungi contribute to the improvement of soil fertility (Grouzis and Le Floch, 2003; Nouredine et al., 2010). These prominent, wide range ecological services

providers are well adapted to the main constraints of arid and semi-arid areas (drought, high temperatures, salinity and extreme light...) therefore, they are valuable trees and good candidates to combat desertification and to integrate any restoration, rehabilitation and reforestation programs in Algeria. Indeed, they have been already included as elite species in the Great Green Wall project, a project of plantation initiated by sahelian countries to fight the desertification progress (Dia and Niang, 2010; Ba, 2010; Hannani and Chehma, 2012).

The propagation and the distribution of these species require higher germination and establishment rates. One of the obstacles of acacias seed germination is the impermeable teguments to water and oxygen causing a physical dormancy (Holmes et al., 1987). In this case, it is necessary to apply pre-germination treatments to overcome the coat dormancy. Several artificial methods have been used to break the dormancy of these seeds, including physical (manual scarification, boiling water and cold water) and chemical pre-germination treatments (sulphuric acid and organic solvents) (Hanna, 1984; Cavanagh, 1987; Côme, 1970; Mousavi et al., 2011; Aref et al., 2011).

In addition, studies of the effects of most frequent environmental stresses encountered in these areas such as salt and water stresses on germination stage are of outmost importance for regeneration and consequently successful establishment of plantations (Aref et al., 2004; Jaouadi et al., 2010).

Studies have been carried out in order to determine the effects of pre-germination treatments, salt and water stresses on acacias seed germination (Teketay, 1996; Al-Mudaris et al., 1999; Ndour et Danthu, 1999; Jaouadi et al., 2004; Aref et al., 2004; Jaouadi et al., 2010; Kassa et al., 2010; Abari et al., 2011).

In Algeria, few published articles focused on these species including the works of Kebbas et al. (2015) and Hannani et al. (2016) on the effects of pre-germination treatments on *A. tortilis* (Forssk.) Hayne subsp. *raddiana* (Savi) Brenan. and the studies of Karoune et al. (2013) and Kebbas et al. (2013) on the characteristics of germination under salt stress of *A. albida* (Del.) A. Chev. and water stress on *A. tortilis* (Forssk.) Hayne subsp. *raddiana* (Savi) Brenan. respectively. Recently, Kheloufi et al., 2016 investigated the germination behaviour and compare the levels of tolerance to salinity in three *Acacia* species (*Acacia delbata* Link., *Acacia ehrenbergiana* Hayne and *Acacia tortilis* (Forssk.) Hayne var. *raddiana*).

A. ehrenbergiana Hayne which is found in the North Sahel, the Southern and Central Sahara, the Arabian Peninsula and East Africa resembles the *A. seyal* Del. Sudano-Sahelian species (Benchelah et al., 2006; Contu, 2012). *A. ehrenbergiana* Hayne grows in dry semi-desert areas where it represents one of the most drought-tolerant species among the common African acacias occurring in the rainfall belts 50-400 mm. In Algeria, this species can be found in Ahaggar, Tassili n'Ajjer and Tinghert Hamada while *A. seyal* Del. stands are rarely found in Ahaggar (Sahki and Sahki, 2004; Contu, 2012). Moreover, *A. ehrenbergiana* Hayne has not been mentioned in the flora dedicated to the Sahara; in Ozenda (1958) and Quezel and Santa (1962-1963); a raison of its confusion with *A. seyal* Del. (Celles and Maniere, 1980; Sahki and Sahki, 2004; Benchelah et al., 2006).

So, this study aims to describe seeds morphological characteristics of *A. ehrenbergiana* Hayne and *A. seyal* Del., two native species of the south of Algeria (Tamanrasset). Furthermore, we determined the effects of pre-germination treatments, salt and water stresses on their germination.

Material and methods

Seeds of *A. ehrenbergiana* Hayne and *A. seyal* Del. were collected from mature pods of healthy trees in 2013 from Tamanrasset (22° 47' 13" North and 5° 31' 38" East) which is located in the south part of Algeria, about 2000 km far from the capital Algiers.

Seeds of *A. ehrenbergiana* Hayne were collected from Amlawlawen area about 15 Km far from Tamanrasset city while *A. seyal* Del. seeds were collected from Taghemout area approximately 50 km far from Tamanrasset city.

In the laboratory of soil biology in 2014, the seeds were removed from their pods, damaged and insect infected seeds were discarded and the empty ones were eliminated using the floating method (Ahmadloo et al., 2011). The seeds were stored at laboratory conditions at 2-5 °C and 80% of humidity.

Seeds were evaluated with both a light microscope (ZEISS Primo Star) and a scanning electron microscope (Jeol JSM 6360LV). Their morphological characteristics: colour, shape, texture, areole shape and position, shape of the hilo-micropylar region, spermoderm brightness, seed weight refers the weight of 1,000 seeds according to ISTA (the average of 10 replicates of 100 seeds weight multiply by 10), size, volume, surface, viability and water content were evaluated (Baldwin, 1942; Justice, 1972; ISTA, 1993).

Effects of pre-germination treatments on acacias seeds germination

Seeds dormancy of acacias species is associated with seed coat impermeability to water and oxygen which constitutes in one hand an adaptive factor for their survival but in the other hand, it is an obstacle for germination even when conditions are optimal. So, in order to overcome the seeds dormancy, we performed three pre-germinations treatment, we applied Manual Scarification (MS) which consists of careful nicking or filing seed coat by hand with a nail clipper on the opposite side of the seed embryo to allow water to inter into seeds. We used Boiling Water (BW) which involves soaking the seeds in boiling water for one hour in order to soften the seed coat. And finally, soaking seeds in concentrated Sulphuric Acid (SA) H₂SO₄ 96% during one hour to weaken seed coat is conducted (Danthu et al., 1992; Ndour, 1997).

In order to minimize any fungal infection of the seeds during the incubation period, seeds were washed with distilled water then their surface were sterilized by immersion in ethanol 70° for 30 seconds and in sodium hypochlorite solution 0.58% for one minute followed by three washes in sterilized distilled water. All these steps were done in a sterile hood.

Five replicates per treatment, with 20 seeds placed in plastic Petri dishes on filter paper were incubated in the darkness because of the seeds light insensitivity (Danthu et al., 2003) at 25°C (primarily experiments) and under a relative humidity of 80%.

Effects of salt and water stresses on acacias seeds germination

From the results of the pre-germination treatments, optimal conditions were determined and used for further experiments. After applying the sterilization and germination protocols, salt stress effects on seeds germination at different levels of NaCl (0, 50, 100, 150, 200, 250, 300 and 350 mM) were evaluated and different solutions of PEG₆₀₀₀ (0, -2, -4, -6, -8 and -10 bars) were used to induce osmotic stress (Michel and Kaufmann, 1973).

The seeds were humidified with NaCl and PEG₆₀₀₀ solutions every 48 h under sterile conditions and counting the germinated seeds which was defined as the emergence of the radical was done.

Determination of germination parameter

The Germination Rate (GR) and Mean Germination Time (MGT) were determined according to Côme (1970).

$$GR = n/N * 100 \quad (Eq.1)$$

Where N is the total number of seeds and n is the number of germinated seeds.

$$MGT = N_1T_1 + N_2T_2 + \dots + N_iT_i / N_1 + N_2 + \dots N_i \quad (Eq.2)$$

Where N_1 is the number of germinated seeds in T_1 and N_2 the number of seeds that germinated between T_1 and T_2 .

Statistical analysis

The data was represented as mean $\pm$ standard deviation (SD). The experiment was made as a completely randomized design with five replicates ($n=5$) of twenty seeds of each replicate. The data were statistically treated by one-way analysis of variance (ANOVA) and the mean values were compared using Newman-Keuls test at $P < 0,05$ to establish the significant differences between each treatment and control.

Results

Seeds characteristics of *A. ehrenbergiana* Hayne and *A. seyal* Del.

The morphological characteristics of the two acacias species studied represented in (Table 1) and (Fig. 1) show some similarities in seeds shape, texture, areole shape and position. *A. ehrenbergiana* Hayne have a light brown colour while *A. seyal* Del. have a greenish brown colour. Morphology of the seeds varied significantly ($P < 0,05$) in length, width, volume, surface and weight of 1000 seeds. The seeds showed a high viability of 90 and 95% for *A. ehrenbergiana* Hayne and *A. seyal* Del. respectively.

Effects of pre-germination treatments on acacias seeds germination

In this work, we investigated the effects of three pre-germination treatments to overcome the seeds dormancy of *A. ehrenbergiana* Hayne and *A. seyal* Del. All pre-germination treatments improved the GR and MGT for both species while the control group presented very low GR (13% for *A. ehrenbergiana* Hayne and 18% for *A. seyal* Del.) and we noticed an increase in the MGT of both species (7,79 days for *A. ehrenbergiana* Hayne and 6,78 days for *A. seyal* Del.).

Table 1. *A. ehrenbergiana* Hayne and *A. seyal* Del. seeds morphological characteristics

Species	Seed colour	Seed shape	Seed texture	Areole shape	Areole position	shape of the hilo-micropylar region	Spermoderm brightness	Weight of 1000 seeds (g)	Seed size (mm)			Volume (mm ³)	Surface (mm ²)	Viability (%)	Water content (%)
									Length	Width	Thickness				
<i>A. ehrenbergiana</i> Hayne	Light brown	Oblong	Smooth	Horseshoe	Subterminal	Round	Slightly shiny	23,26±0,99***	5,67±0,66***	2,58±0,50***	1,06±0,21	21,34±6,20***	36,86±7,18***	95± 0,81*	4,45±2,26
<i>A. seyal</i> Del.	Greenish brown							36,98±0,92***	6,86±0,65***	3,72±0,66***	1,14±0,43	79,80±23,95***	88,82±17,19***	90±2,16*	5,37±1,75

*Mean ± standard deviation, *** very highly significantly different (P< 0,001), * significantly different (P< 0,05) using the Newman-Keuls test*

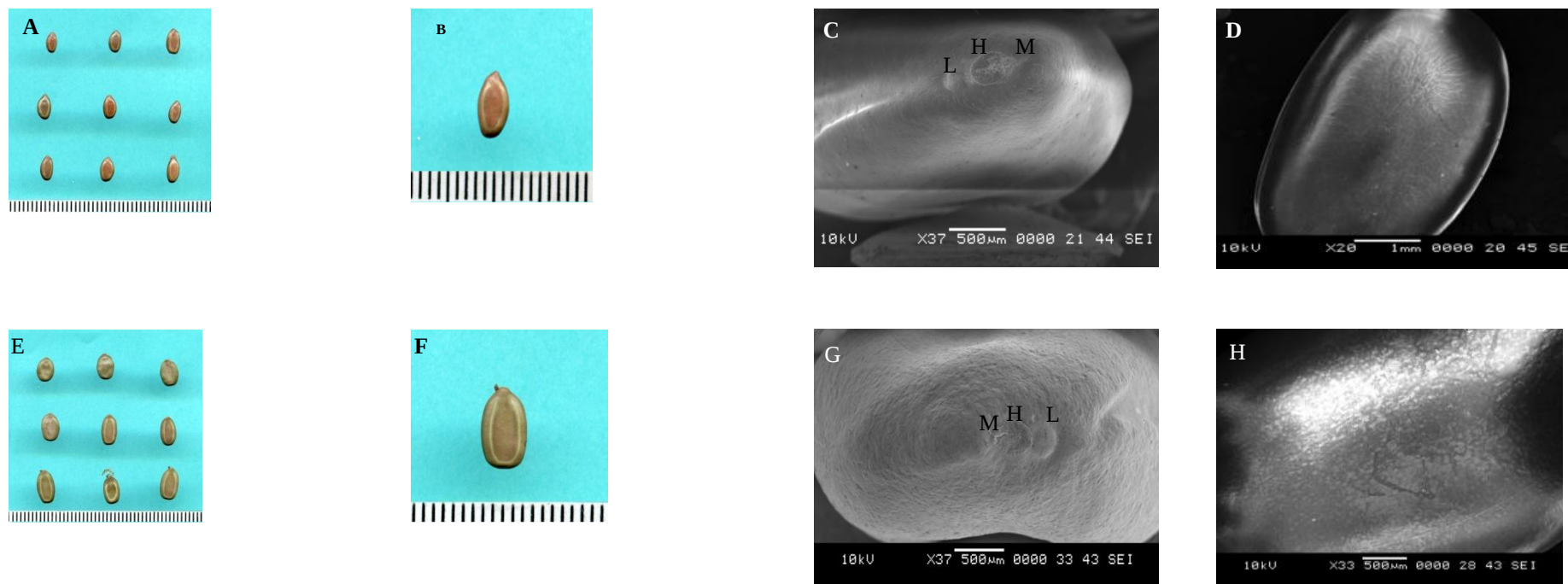


Figure 1. Light microscope and scanning electron microscope study of the seeds morphological characteristics of *A. ehrenbergiana* Hayne (A, B, C and D) and *A. seyal* Del. (E, F, G and H), (L: Lens, H: Hilum and M: Micropyle)

Using sulphuric acid and manual scarification presented high significant difference ($P < 0,001$) compared to the control group with the same and the best effects on *A. ehrenbergiana* Hayne seeds germination while sulphuric acid seems to be the best pre-germination treatment improving GR and MGT of *A. seyal* Del. Moreover, boiling water treatment came in the last position for both species giving a GR three times higher than the untreated seeds and two times lower than sulphuric acid and manual scarification (Fig. 2).

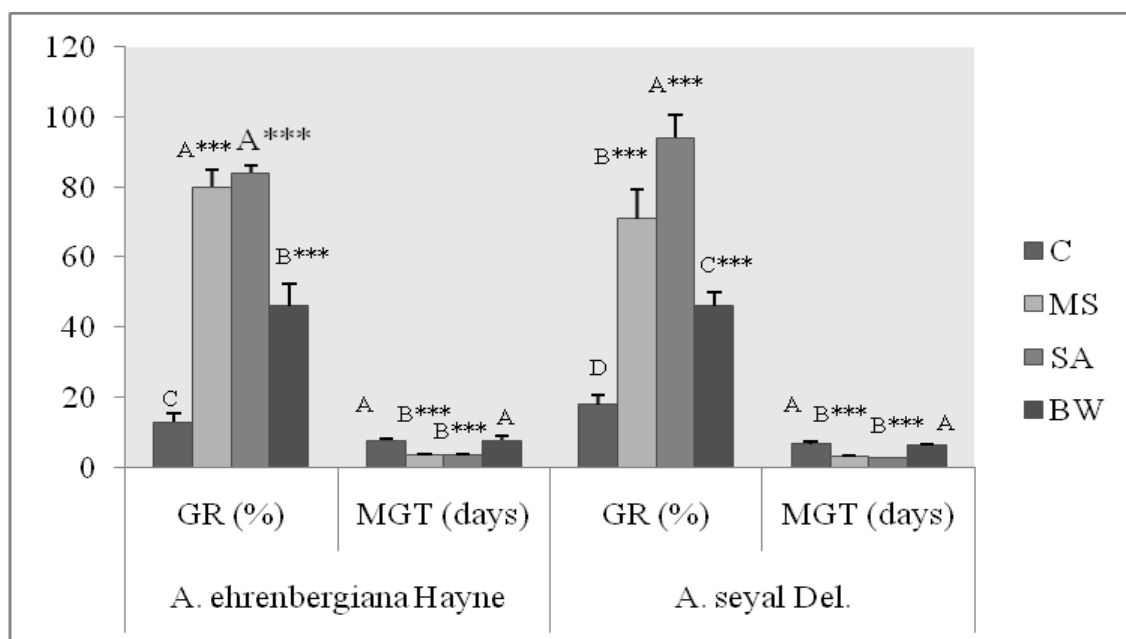


Figure 2. Effects of manual scarification, sulphuric acid and boiling water on *A. ehrenbergiana* Hayne and *A. seyal* Del. seeds germination

Germination rate (GR), Mean Germination Time (MGT), Control (C), Mechanical Scarification (MS), Sulphuric Acid (SA), Boiling Water (BW), $n=5$, *** Very high significant difference with the control ($P < 0,001$), A, B and C statistical similarity between treatments, Means followed by the same letter are not significantly different at $P < 0.05$ using the Newman-Keuls test.

Effects of salt and water stresses on acacias seeds germination

In our study, the germination behaviours under different environmental limiting conditions of salt and water stresses on germination of *A. ehrenbergiana* Hayne and *A. seyal* Del. were investigated.

Our results show that the highest GR and the shortest MGT occurred in the control group and we noticed an inverse correlation between GR and NaCl concentrations. Indeed, increasing salinity levels decreased GR and increased MGT presenting a very high significant difference ($P < 0,001$) compared to control group for both species. Moreover, *A. seyal* Del. seems to be more sensitive than *A. ehrenbergiana* Hayne which germinated even at high levels of salt (at 350 mM) (Table 2).

Table 2. Effects of salt stress on GR and MGT of *A. ehrenbergiana* Hayne and *A. seyal* Del. seeds germination

Species		<i>A. ehrenbergiana</i> Hayne		<i>A. seyal</i> Del.	
Concentration of NaCl (mM)		GR (%)	MGT (days)	GR (%)	MGT (days)
	C	77±2,73	4,7±0,84	82±2,73	4±0,48
	50	63±2,73***	5,39±0,21	68±2,73***	5,28±0,50***
	100	52±2,73***	5,96±0,67**	58±2,73***	5,68±0,46***
	150	42±2,73***	8,47±0,55***	46±4,18***	6,99±0,28***
	200	30±3,53***	8,91±0,25***	33±4,47***	7,52±0,70***
	250	23±2,73***	9,47±1,18***	17±2,73***	9,28±0,29***
	300	16±2,23***	9,63±0,24***	12±2,73***	9,76±0,22***
	350	11±2,23***	10±0,00***	0±0,00***	0±0,00***

Mean ± standard deviation, Germination rate (GR), Mean Germination Time (MGT), Control (C), n=5, *** Very high significant difference with the control (P<0,001), ** high significant difference with the control (P<0,01) using the Newman-Keuls test

Germination assessment of *A. ehrenbergiana* Hayne and *A. seyal* Del. seeds under water stress was investigated using different concentrations of PEG₆₀₀₀. The different water stress levels significantly affected their seeds germination. A reduction in GR and an increased MGT were observed with very high significant difference (P<0,001) when compared with the control group. Thus, seeds of *A. ehrenbergiana* Hayne seems to tolerate high levels of water stress (-10 bars) with a GR of 21% and an MGT of 8,92 days compared to *A. seyal* Del. which could not germinate at -10 bars (Table 3).

Table 3. Effects of water stress on GR and MGT of *A. ehrenbergiana* Hayne and *A. seyal* Del. seeds germination

Species		<i>A. ehrenbergiana</i> Hayne		<i>A. seyal</i> Del.	
Concentrations of PEG ₆₀₀₀ (bars)		GR (%)	MGT (days)	GR (%)	MGT (days)
C		81±2,23	4,70±0,20	78±5,70	3,69±0,63
-2		71±2,23***	5,03±0,59	61±2,23***	5,47±0,42***
-4		60±3,53***	5,54±0,59	48±2,78***	6,12±0,67***
-6		53±2,73***	6,50±0,22***	36±2,23***	7,64±1,00***
-8		41±2,23***	7,49±0,62***	11±2,23***	9,33±0,62***
-10		21±2,23***	8,92±0,46***	0±0,00***	0±0,00***

Mean ± standard deviation, Germination rate (GR), Mean Germination Time (MGT), Control (C), n=5, *** very high significant difference comparing with control (P<0,001) using the Newman-Keuls test

Discussion

Acacia ehrenbergiana Hayne and *Acacia seyal* Del. are two native species to Algeria that have diverse economic and ecological significance. However, their seeds dormancy that causes low germination percentage seems to be problematic for their usage in afforestation or restoration programs.

Seeds characteristics of A. ehrenbergiana Hayne and *A. seyal* Del.

The seeds of *A. ehrenbergiana* Hayne and *A. seyal* Del. that were examined by both a light microscope and a scanning electron microscope presented some morphological similarities in seeds shape and texture, areole shape and position, shape of the hilum-micropylar region and spermoderm brightness and some differences in colour, size, volume, surface and 1000 seeds weight.

We noticed that *A. ehrenbergiana* Hayne seeds are smaller than *A. seyal* Del. seeds while Al-Gohary and Mohamed (2007) found that seeds of *A. seyal* Del. were smaller than those of *A. ehrenbergiana* Hayne. Furthermore, in contrast of our study where we observed a light brown colour of *A. ehrenbergiana* Hayne seeds and a greenish brown colour of *A. seyal* Del. seeds, Waly (2012) reported the dark brown colour of *A. ehrenbergiana* Hayne while Al-Gohary and Mohamed (2007) reported the brown colour of *A. ehrenbergiana* Hayne and the yellowish brown of *A. seyal* Del. seeds.

In our study, seeds of both species have an oblong shape while Al-Gohary and Mohamed (2007) mentioned an obovate shape for *A. seyal* Del. and an oblong shape for *A. ehrenbergiana* Hayne seeds. Due to environmental impact, genetic variations and strategies of adaptation to different environmental conditions and soil types, differences in colour and size were reported by different studies (Al-Gohary and Mohamed, 2007; Waly, 2012; Elmagboul et al., 2014).

The present investigation revealed a significant difference in 1000 seeds weight between the two studied species. In addition, similar results of 1000 seeds weight have been noticed when compared with standard Kew database for both species (26 g for *A. ehrenbergiana* Hayne and 42 g for *A. seyal* Del.).

The water content is a critical factor that influences seed life span and viability; thus, from the results of the water content of *A. ehrenbergiana* Hayne (4,45%) and *A. seyal* Del. (5,37%) we could classify these species as true orthodox seeds implying successful long term storage (Chin et al., 1989).

In the other hand, the viability of the two species was assessed by the tetrazolium test which consists on the measurement of how many seeds in a lot are alive and could develop into plants. This test show high percentages of 95% and 90% of viable seeds of *A. ehrenbergiana* Hayne and *A. seyal* Del. respectively indicating their good conservation. In contrast, the tetrazolium viability test conducted by Al-Hammad and Al-Ammari, 2017 revealed that most non-germinated seeds of *A. ehrenbergiana* (80%) were dead.

Effects of pre-germination treatments on acacias seeds germination

Acacia seeds have a coat dormancy that acts primarily as mechanical barrier limiting water and oxygen entrance. In natural conditions, hard seed coats are broken by fire, extreme temperatures, and digestive acids in animals stomachs or by the abrasion of blowing sand (Luna et al., 2009). In laboratory and nursery conditions, artificial methods are used. According to many authors, manual scarification, sulphuric acid, hot

water and dry heat treatments can break down the coat inhibition (Sadhu and Kaul, 1989; Danthu et al., 1992; Al-Mudaris et al. 1999; Grouzis and Le floc'h, 2003; Abari et al., 2012; Karoune et al., 2013; Rasebeka et al., 2014).

In this study, we tested three methods to overcome seed dormancy in *A. ehrenbergiana* Hayne and *A. seyal* Del. We revealed that manual scarification and sulphuric acid treatments are the best pre-germination treatments for *A. ehrenbergiana* Hayne while sulphuric acid treatment enhanced the GR of *A. seyal* Del. In addition, boiling water presented low germination rates for both species.

The study of Teketay (1996) revealed that manual scarification had the best effect on *A. seyal* Del. seeds where the germination percentage reached 100%. In the other hand, Aref et al. (2011) indicated that manual scarification was the best pre-germination treatments for *A. ehrenbergiana* Hayne seeds where the germination percentage was 96 %, followed by sulphuric acid and boiling water with the germination percentages of 94% and 69 % respectively. In contrast of our findings, the work of Aref et al. (2000) show that boiling water had positive effect on *A. seyal* Del. germination percentage (34.25%) while it has less effect on *A. ehrenbergiana* Hayne germination with a germination percentage of 9.35%.

Effects of salt and water stresses on acacias seeds germination

Seeds germination is a complex process depending on the genetic and environmental factors. Abiotic factors, such as salt and water stresses limit plant germination and growth during early seedling stages (Mansour, 2000). Salt and water stresses affect plants in a similar way. The osmotic effect causes a deficient in water absorption that limits seed imbibition leading to a series of metabolic changes such as the reduction in seed reserves hydrolysis and their use. Salt and water stresses can completely inhibit germination and cause a reduction in plant growth (Ahmad and Bano, 1992).

The effect of salt stress on acacias seeds germination was described by several authors (Ndour and Danthu, 1999; Aref et al., 2004; Abari et al., 2011; Karoune et al., 2013) which showed that increasing salt concentrations decreased the GR of the studied acacias species. However, in all cases, the acacias species were considered as salt tolerant species and Marcar et al. (1991) indicated that acacias species differed in their salt tolerance.

Our results of germination behaviour of *A. ehrenbergiana* Hayne and *A. seyal* Del. show that both species germinated at low concentrations of NaCl (50 mM and 100 mM) with at least 50% GR, while the GR at high concentration (350mM) was decreased to 11% for *A. ehrenbergiana* Hayne seeds and it presented a total inhibition in *A. seyal* Del. seeds. This might be due to the inhibition of the radical emergence as a response to water deficit and their toxic effects on the embryo (Mazher et al., 2007). Jaouadi et al. (2010) suggested that *Acacia tortilis* (Forsk.) Hayne ssp. *raddiana* (Savi) Brenan. is significantly affected by 9 g L⁻¹ of NaCl giving a germination rate of 60%, furthermore, this species continues to germinate even at high concentrations of NaCl reaching 18 g L⁻¹ with a germination rate of 50%. In our case, *A. ehrenbergiana* Hayne could germinate even at high level of NaCl (350 mM = 17g L⁻¹) however it gave a GR of 11%. Also, the study conducted by Kheloufi et al. (2016) revealed that the seeds of *A. ehrenbergiana* Hayne collected in Oued Tin Amezzegin (Tamanrasset, Southern of Algeria) gave a final GR of 100% for the first three seawater treatments (0, 10, and 30 %) and 78 % in the presence of 50% of seawater.

The results of the effect of water stress on *A. ehrenbergiana* Hayne and *A. seyal* Del. seeds showed that GR of both species were significantly affected particularly, *A. seyal* Del. seeds which presented an inhibition at high level of water stress (-10 Bars). Kassa et al. (2010), reported that this species can germinate even at high level of water stress (-12 MPa) and asserted that it is classified as tolerant species to water stress. In addition, Ndour and Danthu (1999) reported that *A. ehrenbergiana* Hayne is more tolerant than *A. seyal* Del. to water stress and both species are considered as tolerate species to water stress because they germinated even at -2,1 MPa.

Our research was lead by the lack of studies on the biology and characteristics of seeds of highly tolerant and beneficial trees in arid areas of Algeria. The present study show some important elements to distinguish between *A. ehrenbergiana* Hayne and *A. seyal* Del regarding their seeds morphological characteristics. In addition, because of their seed coat dormancy, we applied chemical and physical treatments in order to obtain rapid and synchronous germination essential for ensuring seedling establishment. We described the optimal germination conditions of these two species and established their germination behaviour under salt and water stresses two of the most frequent environmental stresses that prevail in arid areas of Algeria. These results are of a significant important as *A. ehrenbergiana* Hayne and *A. seyal* Del. two native species that present a good choice and could be suitable for land rehabilitation, restoration and afforestation programs in these areas.

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