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Assessment of Some Important Tree Species for Production under Arid Zones Conditions

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Abstract: This work aimed to investigate seed germination and growth of five tree species under water stress conditions of arid zones. Two separated experiments were carried out to assess their seed germination and water stress tolerance. The first one studied the effect of four seed treatments, including scarification, soaking in water, soaking in ethanol and control with no treatment, on the germination of three species including *Acacia arabica, Acacia farnesiana and Albizia lebbeck*. The second one assessed water stress tolerance of *Bauhinia variegate* and *Delonix regia* under four water stress levels or irrigation intervals of 1, 2, 4 and 8 weeks under plastic house conditions. The obtained results showed the importance of seed treatment for seed germination where no germination was obtained from control. Scarification was the best seed treatment allowing the highest germination percentage and seedling growth compared to other treatments. The studied species varied in their response to seed treatments where *Acacia arabica* gave the best results. The studied irrigation intervals were effective for the discrimination between the tested species. The assessment of water stress tolerance showed a variability between *Delonix regia* and *Bauhinia variegate* where the first was found to be more tolerant than the last. *D. regia* fully survived under all stress levels however, *B. variegate* did not survived starting from four weeks of drought. Both studied species decreased their growth under stress but *B. varaiegata* was very susceptible. The obtained results showed the possibility of successful production of all the tested trees throughout simple seed treatment. *D. regia* and similar species could be also successfully cultivated under water stress. It could be of great interest to save water in arid zones and enrich them with such economically and ornamentally important trees.

Key words: Trees · Germination · Drought · Water Stress · Arid Regions · Seed Treatment · Irrigation Interval

INTRODUCTION

Production of trees under arid zones conditions faces some barriers because of seed germination problems and water needs which present the main problems facing the diffusion of ornamentally and economically important trees under such zones. Water stress is the most serious threat to agriculture where 40-60% of the agricultural world land suffers from drought [1]. Scarcity of water in arid zones, having limited water resources, is also the main reason of desertification. The trees are very important plants maintaining and preserving the ecosystem of any region. They have multiple ecological and environmental uses besides their role in gardening and bioesthetic planning [2]. Their role is of great importance in arid regions where the environmental conditions are difficult. However, the vital role of water in plant life presents a great barrier preventing the cultivation of trees in arid zones.

Very few numbers of tree species are cultivated under arid zones conditions. *Prosopis* (Family, Leguminosae or Fabaceae) is one of the highest distributed tree in arid zones which is related to its tolerance to drought and its success in dry lands [3]. However, a hypersensitivity to *Prosopis* pollens was reported by different authors in many countries including Saudi Arabia Kuwait, India, South Africa and USA. [4-5]. These findings necessite a research for better alternatives to this well adapted tree. The Leguminosae or Fabaceae family could provide good alternatives to *Prosopis* where it is the third largest family of flowering plants comprising many tree species with multiple economical, environmental and ornamental uses.

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Acacia saligna, Albizia lebbeck, Bauhinia variegate, Cassia fistula, Dalbergia sisso, Enterolobium saman, Erythrina indica, Gleditsia triacanthos, Leucaena glauca, Parkinsonia aculeate, Peltphorum africanum, Poinciana (Delonix) regia, Robinia pseudo-acacia, Tipuana speciosa and Khaya senegalensis are economically and ornamentally important tree species of this family. However, this family has well known physical seed dormancy [6] and the drought tolerance of its species were not assessed.

Seed germination, as the propagation method used for the production of most trees, faces many problems relating to seed coat, internal factors or dormant embryos causing seed dormancy of many tree species [7]. Seeds of most tropical leguminous trees are dormant due to impermeability of the seed coat. Several methods or seed treatments were studied to overcome these problems including seed priming via heat, smoke, soaking, leaching, temperature, scarification, NaCl salinity and *in vitro* techniques [8-9]. Soaking of seeds in water improved germination of cassia species and the highest germination percentage was found with H_2SO_4 scarification [10]. Soaking in ethanol up to 3% (v:v) increased germination of one turfgrass genus but decreased it in two other ones, however, 10% ethanol inhibited germination of all studied genera [6]. Manual nicking and acid scarification improved the germination of *Albizia* and the physical scarification was the best treatment followed by soaking in water [11]. Soaking in concentrated sulfuric acid also improved germination of royal poinciana [12]. We have previously improved the seed germination and seedling growth of some economically important trees including *Delonix regia* and *Bauhinia varigata* [13], however, their drought tolerance is still unknown.

The assessment of drought tolerance is the first step toward the improvement of drought tolerance [14-15]. Beach ecotypes were exposed to water stress under greenhouse conditions to evaluate their drought tolerance [16]. We have determined few indicators allowing an efficient evaluation of pelargonium genotypes for water stress tolerance by withholding water under greenhouse conditions [17-19]. We have also set up methods for the evaluation of drought tolerance under *in vitro* conditions using different osmotic agents [20].

From the previous review, it can be concluded that the enrichment of arid zones by new tree species is indispensable, but the problems related to seed germination and water needs must be investigated. So, the present work aimed to evaluate the production of five economically and ornamentally important tree species of Fabaceae family under arid zones conditions. It was done via the determination of the optimum conditions for seed germination and seedling growth under water stress conditions. The findings could help in identifying some drought tolerant trees of various economical and ornamental characteristics to be produced under arid zones conditions, which subsequently enrich these poor areas and improve their ecological and environmental conditions.

MATERIALS AND METHODS

Establishment of Study: This study was carried out on five tree species of Leguminosae or Fabaceae family including *Acacia arabica, Acacia farnesiana, Albizia lebbeck, Bauhinia variegate and Poinciana (Delonix) regia*. Two separated experiments were performed to determine the optimum condition for seed germination of each specie and assess their tolerance to water stress. Experiments were conducted under plastic house conditions at the Floriculture Experimental Farm, College of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia during two successive seasons 2013 and 2014.

Study of Seed Germination: Seed germination and seedling growth experiments were carried out on three tree species including *Acacia arabica, Acacia farnesiana* and *Albizia lebbeck*. Seeds were obtained from the Agricultural Experimental Farm of Agriculture Faculty, Sohag University, Egypt. Four seed treatments were investigated on the three studied species. The treatments included soaking of seeds in water for 12 hours, physical scarification of seeds, soaking of seeds in ethanol 10% (v:v) for 3 hours followed by water washing and control without any seed treatment. Seeds were cultivated in pots of 30 cm diameter filled by a mixture 2:1 of peat moss and sand. Each treatment contained fifty seeds in four replicates for each species. Irrigation was done regularly and similarly for all treatments and species until the end of experiment. Data were recorded daily starting from the first germination until no further germination.

Assessment of Water Stress Tolerance: This study was conducted on two different species including Orchid tree (*Bauhinia variegate*) and royal poinciana (*Delonix regia*). Seedlings of studied species were transferred individually to pots of 30 cm diameter filled by a mixture 3:1 of soil and organic fertilizer until the beginning of experiment. Water stress was induced by withholding

water from three-months-old seedlings at four different levels expressed as water stress levels or irrigation intervals. Treatments included control or irrigation weekly, –20 KPa. or irrigation every 2 weeks, -40 KPa. or irrigation every 4 weeks and -80 KPa. or irrigation every 8 weeks. These levels were found to be efficient for the assessment of water stress tolerance in pelargonium [19]. Each treatment contained twenty seedlings in four replicates. By the end of experiment, data were collected from all studied treatments.

Experimental Design and Measured Parameters: Seed germination and water stress experiments were arranged in a split plot design with four replicates and each one was repeated twice. The main plots were assigned for the tree species while each main plot consisted of four sub-plots represented the four seed treatments or the four water stress levels. For seed germination and seedling growth experiments, the germination percentage was calculated as the percent of germinating seeds in relation to the total number of cultivated seeds one month after the beginning of experiments. Two months later, stem height (cm) and number of leaves per plant were recorded. By the end of water stress experiment, three months after the beginning of experiments, survival percentage was expressed as the number of surviving plants in relation to the number of tested plants. To eliminate the effect of plant growth nature of studied species, the increment percentages (%) in stem length and number of leaves were calculated by dividing the increment in these parameters during experiment by the original parameters at the beginning of experiment, then multiplying by 100 (the parameter at the end – the parameter at the beginning / the parameter at the beginning × 100).

Statistical Analysis: All data was subjected to analysis of variance (ANOVA) to determine significant differences followed by Tukey's test for the comparison of means at significant level of 5% using S-Plus V. 6 (Professional Release 1; 1988–2001). ANOVA was conducted on the average of the combined data of the two studied seasons for all experiments.

RESULTS

Seed Germination and Seedling Growth: Results in Table (1) show seed germination and seedling growth of three tree species after various seed treatments before cultivation. The studied factors, including tree species and seed treatment, significantly affected all studied parameters. Generally, *Acacia arabica* gave the highest germination percentage compared to the other species. Despite the similar germination percentages of *Acacia farnesiana* and *Albizia lebbeck*, the first showed significantly higher leaves number per plant. Seed treatment by scarification or soaking in ethanol allowed significantly better seed germination and seedling growth than soaking in water. No germination was observed in control with no seed treatment for all studied species (Table 1 and Figure 1). The highest seed germination percentage was obtained from *Acacia arabica* after scarification of seeds or soaking them in ethanol. However, soaking was not effective with *Albizia lebbeck* where scarification of seeds was the only treatment allowed the germination of its seeds. Scarification also permitted similar or higher growth compared to other treatments however, soaking in water gave the least growth (Table 1 and Figure 1).

Fig. 1: Germination of three trees including *A. farnesiana* (1), *Albizia lebbeck* (2) and *A. arabica* (3) under four seed treatments including control (C), soaking in ethanol (E), soaking in water (W) and scarification (S).

Fig. 2: Growth of *Delonix regia* (A) and *Bauhinia variegata* (B) under four irrigation intervals

Table 1: Germination and growth of some trees under different seed treatments, two months after cultivation

Trees	Seed treatment	Germination (%)	Stem length (cm)	Leaves no.
Acacia farnesiana	---	10.0 b	4.0 a	2.7 a
Acacia Arabica	---	32.5 a	4.3 a	2.5 ab
Albizia lebbeck	---	7.5 b	4.0 a	2.0 b
---	Control	0.0 b	---	---
---	Ethanol	30.0 a	4.8 a	2.5 a
---	Water	3.3 b	2.5 b	2.0 b
---	Scarification	33.3 a	4.2 a	2.7 a
Acacia farnesiana	Control	0.0 d	---	---
Acacia farnesiana	Ethanol	20.0 bc	5.0 a	3.0 a
Acacia farnesiana	Water	10.0 cd	2.5 c	2.0 b
Acacia farnesiana	Scarification	10.0 cd	4.5 ab	3.0 a
Acacia arabica	Control	0.0 d	---	---
Acacia arabica	Ethanol	70.0 a	4.5 ab	2.0 b
Acacia arabica	Water	0.0 d	---	---
Acacia arabica	Scarification	60.0 a	4.0 b	3.0 a
Albizia lebbeck	Control	0.0 d	---	---
Albizia lebbeck	Ethanol	0.0 d	---	---
Albizia lebbeck	Water	0.0 d	---	---
Albizia lebbeck	Scarification	30.0 b	4.0 b	2.0 b

Fifty seeds and four replicates per treatment, Means with similar letter at the same column and part are not significantly different at $\alpha = 0.05$.

Table 2: Survival and growth of some trees under different irrigation intervals, two months after transplanting

			Stem length (cm)		Leaves no.	
Trees	Irrigation intervals	Survival percentage	Beginning	Increment %	Beginning	Increment %
Delonix regia	---	100.0 a	10.0	110 a	10.8	90 a
Bauhinia variegata	---	43.8 b	16.5	50 b	2.5	40 b
---	One week	100.0 a	10.0	250 a	4.0	170 a
---	Two weeks	87.5 b	12.5	130 b	9.0	40 b
---	Four weeks	50.0 c	13.0	80 b	8.5	30 b
---	Eight weeks	50.0 c	17.5	20 c	5.0	10 b
Delonix regia	One week	100.0 a	6.0	200 a	6.0	270 a
Delonix regia	Two weeks	100.0 a	11.0	140 a	15.0	30 c
Delonix regia	Four weeks	100.0 a	12.0	50 b	14.0	40 bc
Delonix regia	Eight weeks	100.0 a	11.0	50 b	8.0	30 c
Bauhinia variegata	One week	100.0 a	14.0	70 b	2.0	100 b
Bauhinia variegata	Two weeks	75.0 b	14.0	60 b	3.0	30 c
Bauhinia variegata	Four weeks	0.0 c	14.0	40 b	3.0	30 c
Bauhinia variegata	Eight weeks	0.0 c	24.0	10 c	2.0	0 c

Increment % is calculated as (the parameter at the end – the parameter at the beginning / the parameter at the beginning × 100), Means with similar letter at the same column and part are not significantly different at $\alpha = 0.05$.

Assessment of Water Stress Tolerance: Data in Table (2) show growth of two tree species, *Delonix regia* and *Bauhinia variegata*, under four irrigation intervals presented various water stress levels. Both studied factors and their interaction significantly affected all studied parameters. Generally, *Delonix regia* was more tolerant to water stress where it showed significantly higher survival percentage and higher increments in stem length and leaves number compared to *Bauhinia variegata*. The studied irrigation intervals caused effective water stress where survival percentage and increments in growth decreased with increasing irrigation interval. Survival percentage decreased from 100% under standard irrigation interval, one week, to 50% with four or eight weeks irrigation interval. Increments in growth during water stress period also dramatically decreased starting from the first level of stress for production of leaves and the second level of stress for stem length. Concerning interaction effect, *Delonix regia* seedlings fully survived under all studied irrigation intervals however, *Bauhinia variegate* seedlings partially dead from the first water stress level and no seedling was survived under higher water stress levels (Table 2 and Figure 2). Increment percentages in growth characteristics were highly affected by water stress for both species. Little increments in stem length and number of leaves were recorded on *Bauhinia variegate* seedlings at the beginning of stress followed by their death with the high stress levels. Growth of *Delonix regia* was also affected under water stress and reduction in leaves number was higher than that in stem length but no seedling death was observed under any water stress level.

DISCUSSION

The study aimed to investigate seed germination and seedling growth of some economically important trees under arid zones conditions. The studied tree species of Leguminosae (Fabaceae) have well known physical dormancy relating to impermeability of the seed coat [21]. They were not also evaluated for their tolerance to water stress as the main problem facing afforestation in arid zones. Results showed the effectiveness of studied seed treatments on seed germination where no germination was obtained when seeds were cultivated with no treatment. Scarification of seeds was found to be the best seed treatment for germination and seedling growth of all studied species. The favorable effect of this treatment is probably due to water and gases entering the embryo early through the cracks and causing a series of enzymatic breakdown resulted in the transformation of the embryo into a seedling early enough than other seed treatments [22]. This result is also in agreement with our findings on other tree species of the same family [13]. The studied species differed in their response to some seed treatments as ethanol which is in accordance with results previously obtained by Salehi *et al*. [6]. The negative effect of ethanol was related to its toxicity causing embryo damage or death [7]. The various response between both *Acacia* species and *Albizia lebbeck* proved the effect of genotypic variation. This result was justified by the different response of *Bauhinia variegata* and *Delonix regia* to water stress where the last was found to be more tolerant. This result can be explained by the nature of plant growth and leaves shape where *D. regia* has smaller leaves compared to large leaves of *B. varaiegata* causing large exposing area leading to high evaporation and water loss. The studied irrigation intervals or water stress levels were effective for the discrimination between tolerant and susceptible species which is in agreement with our findings on pelargonium [19]. *B. varigata* was found to be susceptible where four weeks of drought caused death of all plants. The reduction of growth in *D. regia* is considered a mechanism to adapt to stress in tolerant species [23].

CONCLUSION

It can be concluded that some tree species can be produced and cultivated successfully under arid zones conditions. Seed treatment is indispensable for the production of those species. Scarification was found to be the best seed treatment for the germination of all the studied species. The response of studied species to seed treatments was differed. *Acacia arabica* gave higher germination percentage compared to *Acacia farnesiana* and *Albizia lebbeck*. Assessment of water stress tolerance showed that *Delonix regia* is more tolerant than *Bauhinia variegata* where its seedlings completely survived under all the studied water stress levels. Both studied species decreased their growth but *B. varaiegata* seedlings dead at four weeks irrigation intervals. The obtained results showed the possibility of production of many tree species throughout simple seed treatment. *D. regia* and similar species could also be successfully cultivated under water stress. It could be of great interest to save water in arid zones and enrich them with such economically and ornamentally important trees.

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