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Full Length Research Paper

Effect of temperature and salinity on germination of *Achillea fragrantissima* and *Moringa peregrina* from Saudi Arabia

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***Achillea fragrantissima* and *Moringa peregrina* are dominant plants in the mountainous desert of Saudi Arabia. The two species suffer from intensive anthropogenic pressures as they have important medicinal uses. This paper aimed to evaluate the effect of temperature and salinity on germination of *A. fragrantissima* and *M. peregrina* in order to provide information about germination requirements which could be useful for conservation. To this end, seeds of both species were germinated at different constant (5, 15, 25 and 35°C) and alternating temperatures (5/15, 10/20, 15/25, and 25/35°C). Moreover, seeds were germinated under different NaCl concentrations (0, 1000, 2000, 3000, 4000 and 5000 p.p.m.). At both constant and alternating temperatures, seed germination of both species was significantly different among different incubation temperatures. At constant temperature, germination percentage of *A. fragrantissima* and *M. peregrina* was maximum (67.7 and 83.0%, respectively) at 25°C, while at alternating temperatures, the optimal germination (81.0%) of *A. fragrantissima* occurred at 15/25°C, and for *M. peregrine*, it (95.3%) was at 25/35°C. Germination at alternating temperatures is higher than at constant temperatures. Germination of *M. peregrina* occurred at higher temperatures when compared to that of *A. fragrantissima.* Salinity showed significant inhibitory effect on seed germination of the two species. Germination of *A. fragrantissima* seeds was more sensitive to salinity than *M. peregrina*. Maximum seed germination of both species occurred in distilled water, and then germination percentage decreased with increasing NaCl concentration. The lowest germination percentage occurred at 5000 p.p.m. (15.3 and 60.7% for *A. fragrantissma* and *M. peregrina*, respectively).**

Key words: *Achillea fragrantissima*, *Moringa peregrina*, germination, temperature, salinity, desert.

INTRODUCTION

Seed germination is the initial and most crucial stage in the life cycle of plants (Grime and Campbell, 1991). Seed germination is a complex process depending on the genetic constituents of the seeds and on several environmental factors such as temperature, light and salinity (Barbour, 1968; Mahmoud, 1985; Al-Helal et al., 1989). Temperature and salinity are the main limiting factors in the germination of many species in arid regions (Huang et al., 2003; Guma et al., 2010; Wei et al., 2008). For the seeds to germinate, they must imbibe water under a favorable temperature. However, salts and other solutes in the medium cause osmotic inhibitory effects on the seed's water uptake and retard and/or suppress germination. In deserts, temperature has a major influence on determining the onset of germination. It is a main factor limiting the establishment and recruitment of desert species (Adams, 1999; Baskin and Baskin, 1988; Baskin et al., 1999; Budelsky and Galatowitsch, 1999; Ren et al., 2005). The pattern of seed germination in relation to temperature plays an important role in the persistence and dynamics of desert plant populations (Thompson et al., 1977; Meyer et al., 1989; Van Assche and Vanlerberghe, 1989; de Villiers et al., 1994; Cony and Trione, 1996; Demel and Mulualem, 1996; Demel, 1998; Huang, 1998; Tobe et al., 2001; Ren et al., 2005). However, it is not well understood (Ren et al., 2005). Salinity stress affects seed germination either through osmotic effects, by preventing or delaying germination (Welbaum et al., 1990), or through ion toxicity, which can render the seeds unviable (Huang and Reddman, 1995). Sodium chloride is conventionally used to study the effect of salinity (osmotic potential) on germination studies as it is easy to handle (Young et al., 1983). Also, sodium chloride is considered one of the dominant salts in soils of Saudi Arabia (Bashour et al., 1983) as well as other arid regions.

Natural vegetation of most of the world's arid zones as Saudi Arabia are being and have been submitted to strong degrading pressures by human and animal populations (Palmberg, 1985) that lead to its deterioration or even disappearance. This can be treated by revegetation or vegetation restoration projects. To increase the success rate and reduce the cost of these operations, it is essential to have a good understanding of the conditions of germination, that is, the passing from the most-resistant stage (seed) to the most sensitive stage (seedling) of the plant's life-cycle (Gutterman, 1993).

Achillea fragrantissma (Forssk.) Sch. Bip. (Asteraceae) is one of the most valuable species in Saudi Arabian rangelands (Al-Qarawi et al., 1996). It is a perennial herb, white wooly, with erect stems up to 1 m high, old stems are woody, much branched from the base; flowering branches are numerous. Leaves are white to greyish-green, small, thick, sessile, ovate, oblong or oblong-lanceolate, the margins being slightly undulate, shallowly dentate and short mucronate, and the apex is rounded. Flower heads are terminal discoid composed of numerous tubular florets, the ray florets are yellow and very short. The plant flowers from June to September (Batanouny, 1999; Boulos, 2000). The plant is over exploited by collection for folk medicinal uses. An infusion of the dry or fresh flowering herb is used by the local people for the treatment of coughs, aromatic bitter stomachic and anthelmintic. It seems that the rate of collecting plants exceeds that of regeneration. The plant may therefore be considered threatened (Batanouny, 1999; Al–Gaby and Allam, 2000).

Moringa peregrina (Forssk.) Fiori (Moringaceae) is a tree (4 to 15 m) that produces leaves with tiny leaflets, only to drop them as the leaf matures. However, the naked leaf axis remains and represents the main photosynthetic organ of the tree. Flowers are 1 to 1.5 cm long and pinkish white or pale yellow. Fruits are relatively large pendulous capsules (10 - 25 × 1 - 1.5 cm^2) each containing 5 to 15 large ovoid-trigonous seeds (1.2 - 1.5 × 0.8 - 1 cm^2) (Boulos, 1999). *M. peregrina* has medicinal importance: the seeds are rich in oil which is valuable for lubricating delicate machinery such as watches and scientific apparatuses, seeds are also used as laxative in folk medicine, plants are used as firewood and inflorescences are used to feed livestock (Hegazy et al., 2008). Due to the over-exploitation of seeds and trees, the species is threatened in the region of the Red Sea (Hegazy et al., 2008).

Little information is available concerning the germination responses of *A. fragrantissma* and *M. peregrina* to temperature and salinity. Given the importance of these parameters in research and revegetation projects, the focus of this paper is to study the germination response of *A. fragrantissma* and *M. peregrina* to different temperatures and salinity levels.

MATERIALS AND METHODS

Collection of plant material

Mature inflorescences of *A. fragrantissma* and pods of *M. peregrina* were collected during July 2009 from two large populations in Tabuk region, Saudi Arabia. The collected materials were air dried for one week, and then seeds were separated from inflorescences of *A. fragrantissma* and pods of *M. peregrina*. The seeds were stored inside paper bags and kept in darkness at room temperature until germination in January 2010. Seeds used in germination experiments were not scarified.

Germination experiments

To determine the effect of temperature on germination, seeds were incubated under four constant temperature regimes: 5, 15, 25 and 35°C, and four alternating temperature regimes of 5/15, 10/20, 15/25, and 25/35°C based on a 24-h cycle of 12 h. These temperature regimes represent the seasonal common temperatures prevailing in the natural habitats where the study species grow. To test the effect of salinity on germination, seeds were germinated in distilled water (control), 1000, 2000, 3000, 4000 and 5000 p.p.m. NaCl under the optimum temperature regimes based on the results of the earlier experiment (15/25 and 25/35°C for *A. fragrantissma* and *M. peregrina*, respectively). Percentage of germination was recorded after ten days. The germination was conducted in 15-cm Petri dishes containing two layers of Whatman No. 1 filter paper wetted with 10 ml of distilled water or with aqueous solutions of NaCl. Germination experiments were conducted in un-illuminated incubator. Three replicates of 25 seeds each were used for each treatment. Seeds were considered to be germinated with the emergence of the radicles. Germination percentage was calculated as the proportion of germinating seeds within a replicate.

Statistical analysis

Seed germination percentages were expressed as mean ± SD. The data were subjected to one-way analysis of variance (ANOVA) and Tukey's post-hoc test was used to identify significant differences among treatment means at $P < 0.05$ for temperature and salinity. Statistical analysis was done with the Statistical Package for the Social Sciences (SPSS) 11.1 for Windows statistical software package.

RESULTS AND DISCUSSION

At constant temperatures, the highest germination percentage of *A. fragrantissma* (67.7%) was observed when seeds were germinated at 25°C followed by 15 and 35°C that caused germination percentages of 59.0 and 53.0%, respectively. The lowest germination percentage (39.7%) was observed at 5°C. Germination percentages were significantly different between different constant temperatures ($P < 0.05$) (Figure 1). The germination percentage of *A. fragrantissma* seeds under alternating temperatures

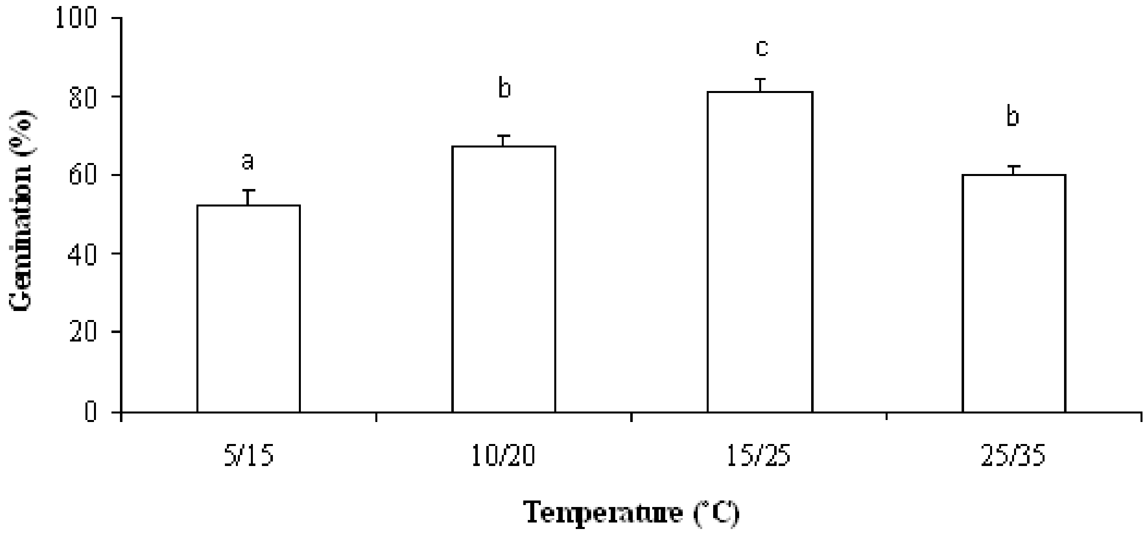

Figure 1. Effect of constant temperatures on germination percentage of *A. fragrantissma*. Bars represent 1 SD. Temperature treatments sharing the same letter are not significantly different at the 0.05 level.

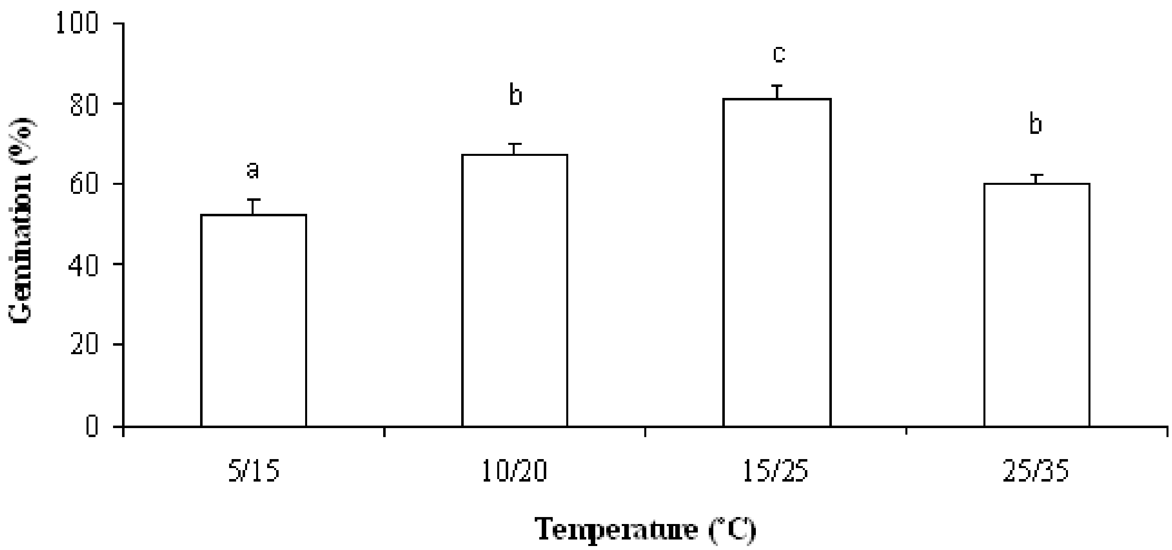

Figure 2. Effect of alternating temperatures on germination percentage of *A. fragrantissma*. Bars represent 1 SD. Temperature treatments sharing the same letter are not significantly different at the 0.05 level.

is shown in Figure 2. The germination percentages increased with rise of temperature attaining their maximum of 81.0% at 15/25°C, then decreased to 60.0% at 25/35°C. The lowest germination percentage (52.0%) occurred when seeds were incubated at the alternating temperatures of 5/15°C. The germination percentages are significantly different between the different alternating temperatures applied ($P < 0.05$). Generally, the percentages of germination at alternating temperatures are higher than at constant temperatures.

The percentage of germination of *M. peregrina* seeds that germinated at constant temperature increased significantly with the rise of temperature till 25°C which showed the highest germination of 83%, then decreased at 35°C (79.7%). No germination occurred at 5°C. So, among the constant temperature regimes tested, the germination of *M. peregrina* was restricted to the temperature range 15 to 35°C (Figure 3). At alternating temperatures, the germination percentage of seeds increased with the rise of temperature. The percentages of germination were higher at 15/25°C (91%), 25/35°C (95.3%) and 10/20°C (76.0%) when compared to 5/15°C which showed germination percentage of 19.3% (Figure 4). It is obvious that for both species, germination at

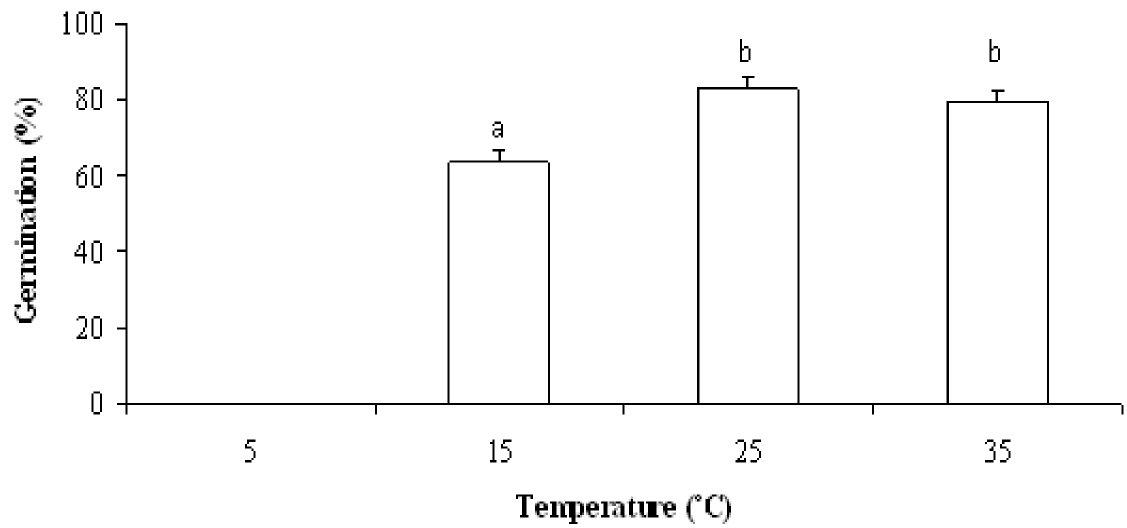

Figure 3. Effect of constant temperatures on germination percentage of *M. peregrina*. Bars represent 1 SD. Temperature treatments sharing the same letter are not significantly different at the 0.05 level.

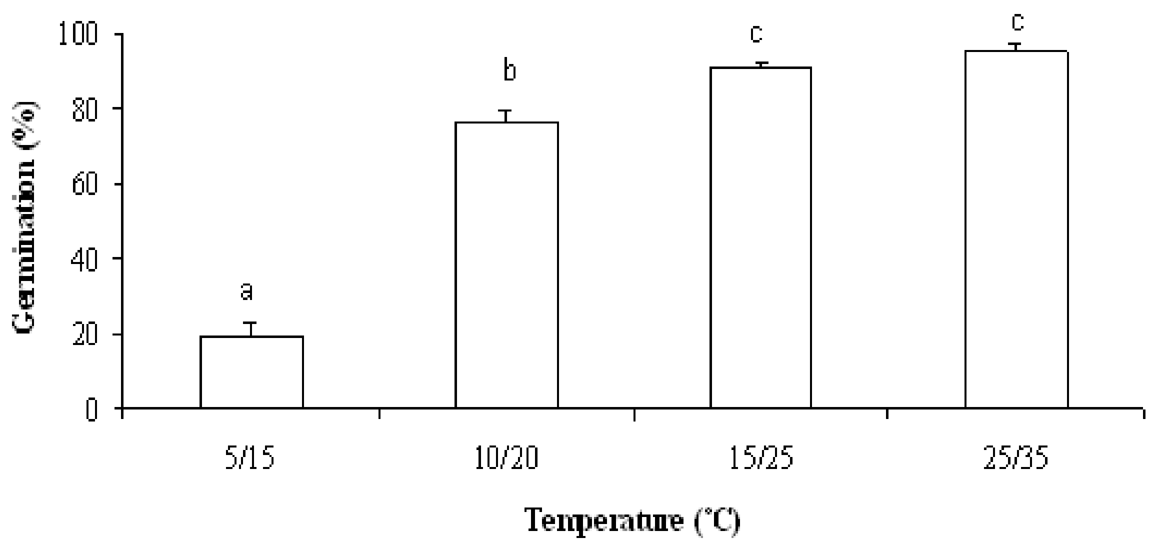

Figure 4. Effect of alternating temperatures on germination percentage of *M. peregrina*. Bars represent 1 SD. Temperature treatments sharing the same letter are not significantly different at the 0.05 level.

alternating temperatures is higher than at constant temperatures. Several species from arid zones have shown higher germination percentages under alternating temperatures than under constant temperatures (Mahmoud et al., 1983, 1984; Ortega-Baes and Rojas-Aréchiga, 2007).

Within the temperature interval where seeds from any species germinate, there exists an optimum, above and below in which germination is delayed but not prevented (Mayer and Poljakoff-Mayber, 1982). According to these authors, the optimum temperature is that in which the seeds of a particular species reach the highest germination percentage in the shortest time. Using this criterion, the optimum germination temperatures for *A. fragrantissma* seeds were 15/25°C, while for *M. peregrina* they were 25/35°C, that is, *A. fragrantissma* shows lower optimum temperature than *M. peregrina*. Germination of *A. fragrantissma* occurred at lower temperatures when compared to germination of *M. peregrine*, but generally, both species germinated better at relatively high temperatures that correspond to field conditions during spring. This agrees with the results of Qarawi et al. (1996) who pointed out that *A. fragrantissima* germinate best during spring-time.

Salinity showed significant inhibitory effect on seed germination of the two study species ($P < 0.05$) (Figures

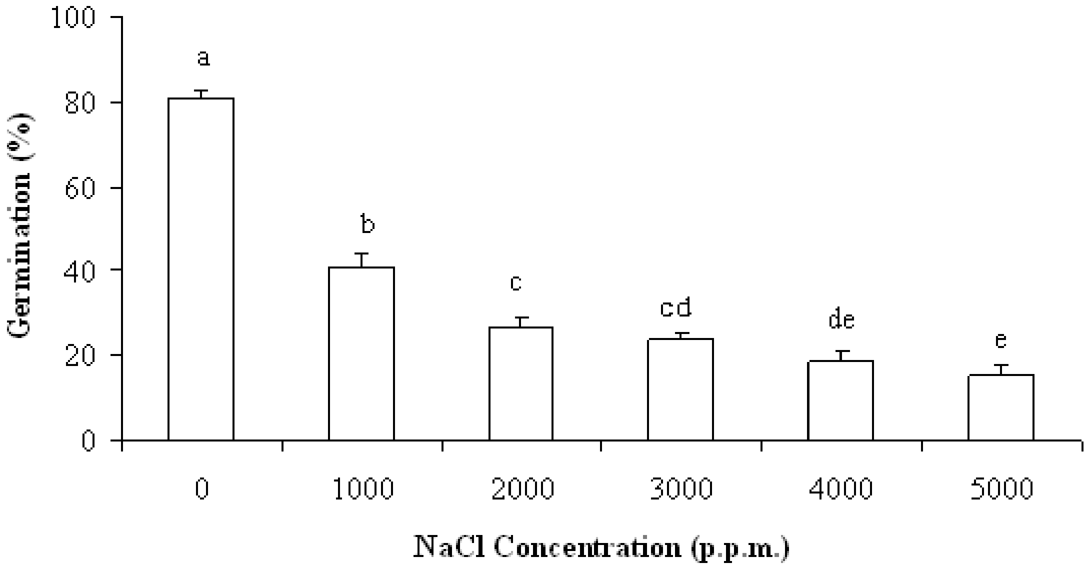

Figure 5. Effect of salinity on germination percentage of *A. fragrantissma*. Bars represent 1 SD. NaCl treatments sharing the same letter are not significantly different at the 0.05 level.

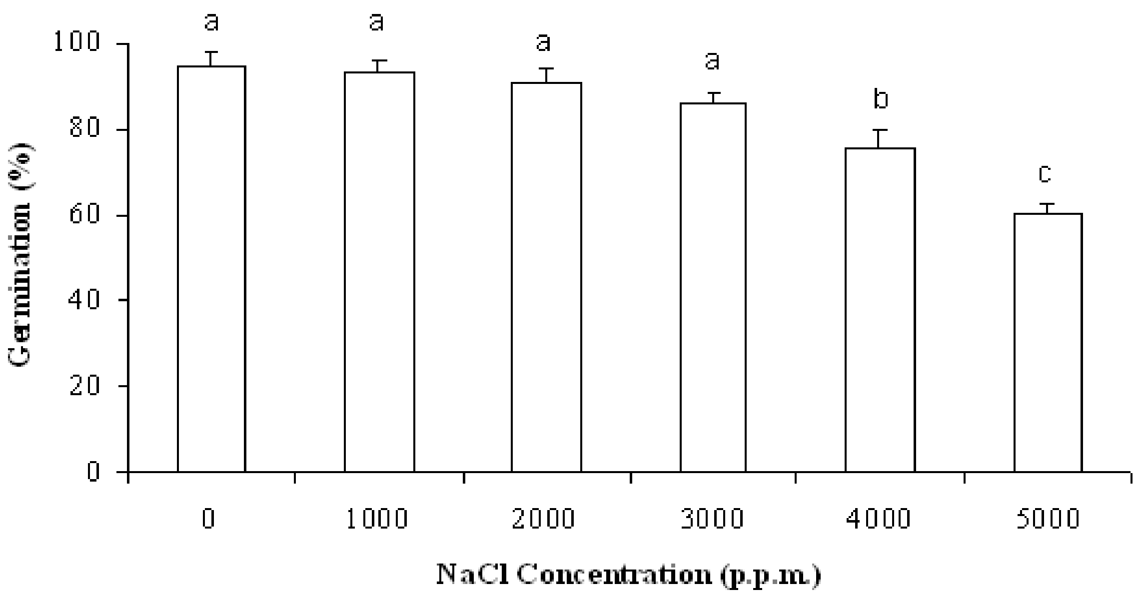

Figure 6. Effect of salinity on germination percentage of *M. peregrina*. Bars represent 1 SD. NaCl treatments sharing the same letter are not significantly different at the 0.05 level.

5 and 6). Maximum seed germination of *A. fragrantissma* and *M. peregrina* occurred in distilled water (80.7 and 94.7%, respectively). Germination percentage decreased with increasing NaCl concentration. The lowest germination percentage occurred at 5000 p.p.m. (15.3 and 60.7% for *A. fragrantissma* and *M. peregrina*, respecttively). Germination of *A. fragrantissma* is more sensitive to increasing salinity than *M. peregrina*. The inhibitory effect of high salinity on germination of desert plants have been reported in previous studies (El-Keblawy and Al-Rawai, 2005; Guma et al., 2010; Wei et al., 2008). In general, salinity affects germination by creating a potential sufficiently low to inhibit water uptake and/or by providing conditions for the entry of ions that may be toxic to the embryo (Bewley and Black, 1982).

Conclusively, germination at alternating temperatures is higher than at constant temperatures for both species. The germination of *M. peregrina* seeds is favoured by relatively high temperatures with maximum germination at 25/35°C when compared with that of *A. fragrantissima* with maximum germination at 15/25°C. Seed germination of *A. fragrantissma* is more sensitive to salinity when compared with *M. peregrine*, indicating that seeds of *M. peregrina* can be efficient in revegetating salt affected soils, while those of *A. fragrantissma* cannot. Finally, the present study provides information about germination requirements which could be used for conservation studies.

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