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Germination Assessment for Five Species of *Acacia* in Jibala, Saudi Arabia

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Abstract: Most *Acacia* species have a hard seed coat and therefore have become more resistant to unsuitable environmental conditions. The study aimed to assess the effects of different treatments on seed germination collected from five species of *Acacia* in Jibala, Al-Dawadmy, a city located in the Riyadh region of Saudi Arabia. The results showed that the highest germination percentage was 90.8%, with scarification treatment, while the lowest germination percentage was 30.9%, utilising a boiling treatment lasting seven minutes. Among the studied species, the seeds of *A. ehrenbergiana* produced the highest percentage of germination and the lowest germination time average among the studied species, while the lowest germination percentage and the highest germination time averages were found in *A. nubica*. Concluding, this study proved that scarification was the most effective technique for increasing germination rates, compared to other treatments.

Keywords: *Acacia* Species, Scarification, Boiling, Treatment, Socking, Germination

Introduction

The genus *Acacia* is one of the most important tree components of the flora in Saudi Arabia (Aref et al., 2003). *Acacia* spp. is widely distributed in arid and semi-arid regions. (Demel, 1996; Wilson and Witkowski, 1998). *Acacia* is currently attracting great interest due to their drought resistance (Oba et al., 2001) and multiple uses, including fodder, wood and non-wood products (gums, resins and pharmaceuticals) for local communities, provision of shade and live fencing (Noad and Birnie, 1989) and in maintaining soil fertility through nitrogen fixation (Belsky et al., 1989). It is also well known that *Acacia* species are very important sources of non-wood products in arid and semi-arid environments (Kassa et al., 2010).

FAO (2007) estimated worldwide annual deforestation at 13 million ha or 0.7% of the total forested area. The germination process is considered the most important and crucial factor in a plant life cycle, as it seriously affects the successful execution of afforestation and reforestation programmes (Vibekke et al., 2004; Bu et al., 2008). Numerous techniques have been used to render *Acacia* and other seeds permeable, including scarification and soaking in tap water, boiling or hot water, acids, organic solvents and alcohols (Bonner et al., 1974; Clemens et al., 1977; Zwaan, 1978; Delwaulle, 1979; Cavanagh, 1980a; ISTA, 1981; Ren and Tao, 2004; Patane and Gresta, 2006; Okunomo and Bosah, 2007; Kassa et al., 2010). Most *Acacia* spp. have hard seed coats impervious to water (Demel, 1996; Baskin and Baskin, 1998; Walters et al., 2004). One of the characteristics of the seeds of some desert species, especially those affiliated with the family *Fabaceae*, such as *Acacia tortilis* and *Acacia gerradii*, is a thick testa that does not allow water to enter, so the seed cannot grow unless it is carried away from the native plant and part of it is scraped by rocks and gravel or by exposure to different temperatures and high humidity, all of which can lead to its softening and rendering in water (Alnafia 1425). *A. negrii* seeds were studied (Demel, 1996) and it has been shown that seed testa can be broken by mechanical scratching, acid treatment, boiling water, and by a dry heating treatment. All previous treatments have improved and increased the germination rate of many species of acacia. In a study conducted by Okunomo and Bosah (2007), several treatments were used to germinate seeds of *A. senegal* in Nigeria. The most important of those treatments were immersion in warm water at 60˚m and 28˚m for 5, 10, 15, or 20 minutes, plus a control, and cold-water immersion for 12, 24, 48, or 72 hours. Finally, the experimenters used diluted sulphuric acid for 5, 15, and 20 minutes, plus a control. The results showed that a 20-minute seed-acid treatment gave the highest germination percentage, 90%. This compares to other acid treatments yielding germination in three days, while the rate for immersion in cold water for 48 hours is

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higher by comparison. Other cold-water immersion periods yielded a 60% germination rate after 21 days.

Scarification can be carried out in a number of ways, both manual and mechanical, all designed to remove part of the seed's coat so as to allow access to water straight to the foetus. This is an appropriate treatment of small seed quantities for research purposes (Msanga 1998). Wolf and Kamondo (1993) showed that scarification is an effective means of breaking cumin in seed in a number of trees, including *A. tortilis* and *A. seyal*, and that approach has been used for small quantities of seeds in scientific research. For example, Bockarie et al. (1993) successfully used sandpaper to break cumin seeds in *Cassia sieberian*, an approach which resulted in high and ideal germination. This study therefore sought to assess the effects of four treatments (acid, boiling, soaking and scarification) on five species of *Acacia*.

Materials and Methods

Jibala, the area studied, is located in Al-Dawadmi and is one of the rarest areas populated by *acacia* species in the Riyadh region. Jibala lies in the north-western portion of the region, around 80 km from the city of Al-Dawadmy, at coordinates 24°48'11.0"N and 43°53'27.2"E, at an altitude of nearly 924 m above sea level (Fig.1.).

Environmental Data

Climate data was collected by Buryadh station, the station nearest the study area. The data was utilised to identify thermal rain factors from 1985 to 2008 (Table 1), using Emberger's equation (Emberger, 1971).

Emberger's equation:

$$Q^2 = \frac{2000P}{M^2 - m^2}$$

Where

(Q^2) is pluviometric coefficient.

(P) is the mean of rainfall each year (ml).

(M) is the mean of the highest temperatures each month.

(m) is the mean of lowest temperatures each month.

The mean of highest (M), lowest (m) temperature and rainfall rate (P) for the whole period were calculated as follows:

P = 138.25 x 2000

P = 276500

M = the mean highest temperature + thermodynamic temperature

M = 43.9+273=316.9

M^2 = 100425.61

M = the mean lowest temperature + thermodynamic temperature

M = 6.02+273 = 316.9

M^2 = 77852.16

$$Q^2 = \frac{2000P}{M^2 + m^2}$$

$$Q^2 = \frac{276500}{100425.61+77852.16}$$

Q^2 = 12.25

This result was presented by Emberger graph to identify the climate location for the Buryadh station. Climate data from 1985 to 2008 at Buryadh station (Table 1) showed that the highest temperatures ranged between 46.1° and 42° during June, July and August each year, while the lowest temperatures ranged between 2.3° and 10.9° during December, January and February of each year (Figure 2).

The annual rainfall rate from 1985 to 2008 at Buryadh station ranged between 55 mm and 248.6 mm each year (Fig.2.). Climate location for Buryadh station was presented by Emberger's factor and it's located in a very dry zone (Saharan), based upon climate data of Buryadh station at 12.25 (Fig.4.).

Seeds collection and experimental Design

Seeds were collected from the various species by shaking trees and were then stored in plastic tanks to transport to the laboratory. Experimental Design followed methods described by Aref et al. (2011), Four treatments were used: sulphuric acid (98%) for five periods of 5, 10, 15, 20 and 25 minutes; boiling at 100 C° for four periods, 1, 3, 5 and 7 minutes; soaking for periods of 24, 48 and 72 hours; and scarification: seeds were scarified manually by cutting 1 mm of the seed coat. A total of 25 seeds were placed on three layers of Whatman filter paper No. 3 in 9 cm Petri dishes. Four replicates were used for each treatment, plus the control. Filter papers were kept moistened and distilled water was added whenever needed throughout the duration of the experiments. Petri dishes were kept in a Weiss Technik growth chamber) at a constant temperature (30 ± 1°C) and 12/12 h light and darkness. Germination was monitored daily and recorded. Seeds were considered germinated when the healthy, white radical had emerged through the integument.

Determination of germination parameters.

The following germination parameters were determined by:

(1) Germination percentage (GP); the number of germinated seeds as a percentage of the total number of tested seeds is given as:

GP = (germinated seeds/total tested seeds) × 100%

(2) Germination mean time, given according to Scott et al. (1984) as:

(GMT days): = Σti Ni / S

Where ti is the number of days from the beginning of the experiment, Ni the number of seeds germinated per day and S is the total number of seeds germinated.

(3) Coefficient of variation of the germination time is calculated by the expression,

$$CV_t = \frac{s_t}{\bar{t}} 100$$

Where st: standard deviation of the germination time and t̄: mean germination time. An Excel function was used to calculate*: =SQRT ((G17/ (C17-1))/C19*100*. Replications or samples with only one seed germinated do not have the value of this measurement because the divisor of the variance of the germination time is zero.

Results

Statistical analysis of the influence of seeds treatments on germination rates for five species of acacia showed that in A. ehrenbergiana there was no significant difference between mechanical scarification treatments, acid treatments, boiling 7 minutes and soaking 24 hours, while there was significant difference in germination rates between acid treatments and boiling 3 or 5 minutes —79% and 72%, respectively. There was also significant difference in germination rates between acid treatments, 92% and 97%, and soaking treatments of 48 and 72 hours, which were 73% and 77%, respectively. The highest germination was in *A. gerardii var. najednsis* by mechanical scarification which was 100% (Table 2). In A. nubica, the differences between mechanical scarification treatment and other treatments in germination rate were significant. The highest germination rate was 53% in mechanical scarification treatment, compared to other treatments, while there were not significant differences between boiling treatments. In *A. raddiana*, the highest germination rate was 97% in mechanical scarification treatment, while other treatments did not result in a significant difference. There was, however, significant difference in *A. tortilis* between boiling treatments 1, 5 and 7 minutes, with germination rates of 70%, 47% and 34%, respectively (Table 2).

The highest germination rate in *A. Ehrenbergiana* was 97% with acid treatment of 15 minutes, while the lowest germination rate was 72%, produced by a boiling treatment of 5 minutes (Fig.5.). Germination treatments in *A. gerardii* revealed that the highest germination rate was 90% with mechanical scarification treatment, whereas the lowest germination rate was 6% generated by soaking for 72 hours (Fig.6.). The germination rate of *A. raddiana* and *A. tortilis* was the highest with mechanical scarification treatment, 97% and 93%, respectively, while the lowest germination rate in *A. raddiana* was 18% by several treatments, including control, boiling 7 minutes and soaking 48 hours, but in *A. tortilis* the rate was 43%, produced by boiling for 7 minutes (Fig.7 and 8.). The lowest germination rate was 0% in *A. nubica* by the control treatment, whereas the highest was 53% by mechanical scarification (Fig.9.).

Germination rate was influenced by treatments, with mechanical scarification generating the highest coefficient of velocity of germination (CV) and germination percentage. While it was the lowest in mean germination time (MGT) (Table 3). Germination rate was also influenced by species. The coefficient of velocity of germination (CV) was the highest in *A. ehrenbergiana* while it was the lowest in *A. nubica*. In contrast, mean germination time (MGT) was the highest in *A. nubica*, whereas MGT was the lowest in *A. ehrenbergiana.* Germination percentage was the highest in *A. ehrenbergiana* and the lowest in *A. nubica.*

Discussion

Most plants in arid zones which have hard seed coats have become more resistant to unsuitable environmental conditions (Washitani and Masuda, 1990; Fenner, 1991; Meyer et al., 1991; Silvertown, 1999). In this particular environment, seeds take a long time to grow into seedlings (Morgan, Wang et al., 1998). Breaking seed dormancy is an important factor in producing a large number of seedlings (Lodge and Whalley, 2002), and germination treatment is an effective and important method of breaking seed dormancy.

In this study, germination treatments created high germination rates in most *acacia* seeds. Scarification treatment was more productive than other treatments because germination was better and faster in all five tested species of acacia. This confirmed that seeds of some desert species, including *Acacia tortilis*, *Acacia gerrardii and Acacia tortilis*, needs to be removed from the native plant and part of it scraped to allow water entry inside the seed (Alnafia 1425). Scarification also proved an appropriate treatment of small seed quantities for research purposes (Msanga 1998). Bockarie et al. (1993) used sandpaper to break cumin seeds for *Cassia sieberiana* and this produced high and ideal germination rates. Acid treatment was also effective, but its cost was high and its use was dangerous compared to other treatments, according to Bonner et al. (1974). Boiling treatment produced less germination than acid treatment because acid has the ability to breach the seed coat barrier to enable imbibition and germination to take place (Masamba, C., 1994). Soaking treatment also was more effective than the control, and it enhanced germination rate in many species, including *Acacia mearnsii*, *A. melanoxylon*, *A. nilotica*, and *A. procera* (Matias et al. 1973).

Conclusion

Germination rates in all *acacia* seeds were varied between treatments, but all were significantly improved by those treatments. Mean germination time (MGT) was between 3 and 9 days for all acacia species which were studied. *A. ehrenbergiana* had the highest germination rate and the lowest in mean germination time compared to other species. In contrast, A. nubica had the lowest germination rate and the highest mean germination time. This occurred because nubica seeds have a thick, strong testa, which requires particular treatments to break cumin in seed (Wolf and Kamondo 1993). As a result, acacia seed characteristics have become better at breaking cumin and germinated more quickly

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Year	The highest temperature	Month	The lowest temperature	Month	Rainfall rate (P)
1985	42.4	8	6.5	2	140.9
1986	42.8	8	6.1	1	161.3
1987	44.2	7	5.44	1	118.5
1988	42.7	7	7	1	86.2
1989	43	7	10.9	1	96.2
1990	42.5	7	5.5	1	55
1991	42	6	7	1	163
1992	42	8	2.3	1	194.9
1993	42.9	8	5.6	1	199.2
1994	42.4	8	6.6	12	129.6
1995	43.6	8	7.39	1	248.6
1996	44.5	7	8.58	1	127.3
1997	43.4	6	5.3	2	240.5
1998	46.1	8	6	1	108.6
1999	44.9	8	6.5	12	99
2000	45.8	8	5.8	1	156.1
2001	46	8	4.5	1	152.1
2002	45	7	6.2	1	155.6
2003	45.3	8	5.2	1	78.5
2004	44.5	7	5.68	1	159.8
2005	43.9	8	5.79	1	202.8
2006	44.5	8	4.8	12	79.6
2007	44	8	4.8	1	64.3
2008	44.8	8	4.9	1	100.3
Average	The mean of highest temperature		The mean of lowest temperature		The mean of rainfall rate
	(M)= 43.9		(m)= 6		(P)= 138.25

Table 1. The average of highest and lowest temperatures and rainfall rate at Buryadh station from 1985 to 2008

Source: The General Authority of Meteorology and Environmental Protection

Table 2. The influence of treatments on germination rate for five species of acacia.

Treatments	Species				
	A. ehrenbergiana	*A. gerradii var. najednsis*	*A. nubica*	*A. raddiana*	*A. tortilis*
mechanical scarification	91^{bdac}	100^{a}	53^{a}	97^{a}	93^{a}
Acid 5 minutes	93^{ab}	13^{fe}	4^{ced}	21^{cd}	83^{bac}
Acid 10 minutes	92^{abc}	16^{fed}	4^{ced}	25^{cd}	83^{bac}
Acid 15minutes	97^{a}	26^{cbd}	8^{b}	44^{b}	91^{a}
Acid 20minutes	94^{ab}	15^{fed}	4^{ced}	39^{b}	92^{a}
Acid 25 minutes	93^{ab}	23^{ced}	4^{ced}	34^{cb}	89^{ba}
Boiling one minute	81^{bdec}	34^{cb}	1^{fe}	22^{cb}	70^{c}
Boiling 3 minutes	79^{dec}	38^{b}	2^{fed}	20^{d}	83^{bac}
Boiling 5 minutes	72^{e}	33^{cb}	6^{cb}	21^{cd}	47^{d}
Boiling 7 minutes	93^{ab}	31^{cb}	5^{cbd}	18^{d}	34^{d}
Soaking 24 hours	92^{abc}	10^{f}	7^{cb}	19^{d}	72^{bc}
Soaking 48 hours	73^{e}	11^{fe}	6^{cb}	18^{d}	82^{bac}
Soaking 72 hours	77^{e}	6^{f}	4^{ced}	21^{cd}	82^{bac}
control	78^{de}	8^{f}	0^{f}	18^{d}	90^{a}
L.S.D	13.5	12.6	3.7	13.9	17.2

L.S.D= Least Significant Difference. Means followed by the same letter in a column are not significantly different at $P < 0.05$.

Table 3. The influence of treatments on coefficient of velocity, mean germination time and germination percentage.

Treatments	Coefficient of velocity of germination - % (CV)	Mean germination time - days (MGT)	Germination percentage - % (GP)
mechanical scarification	0.41^{a}	3.1^{i}	90.8^{a}
Acid 5 minutes	0.26^{dc}	4.9^{gef}	42.9^{cd}
Acid 10 minutes	0.37^{ba}	3.7^{gif}	42.9^{cd}
Acid 15minutes	0.31^{bc}	4.6^{gefh}	56.5^{b}
Acid 20minutes	0.36^{ba}	3.92^{gifh}	49^{cb}
Acid 25 minutes	0.37^{ba}	3.4^{ih}	49.5^{cb}
Boiling one minute	0.21^{de}	6.7^{bc}	37.8^{fde}
Boiling 3 minutes	0.21^{de}	6.4^{bcd}	41.8^{cde}
Boiling 5 minutes	0.20^{de}	5.9^{becd}	32.9^{fe}
Boiling 7 minutes	0.21^{de}	5.2^{efd}	30.9^{f}
Soaking 24 hours	0.20^{de}	7.19^{ba}	38.8^{fde}
Soaking 48 hours	0.24^{de}	5.47^{bcd}	35^{fde}
Soaking 72 hours	0.21^{de}	6.46^{bcd}	35.2^{fde}
control	0.18^{e}	8.25^{a}	34^{fde}
L.S.D	0.069	1.4	4.8

L.S.D= Least Significant Difference. Means followed by the same letter in a column are not significantly different •at $P < 0.05$.

Table 4. The influence of species on coefficient of velocity, mean germination time and germination percentage.

Species	Coefficient of velocity of germination-% (CV)	Mean germination time – days (MGT)	Germination percentage - % (GP)
A. raddiana	0.29[b]	4.18[c]	29.9[c]
A. ehrenbergiana	0.38[a]	3.13[d]	88.5[a]
A. gerradii	0.26[b]	5.5[b]	22.8[d]
A. tortilis	0.28[b]	4.7[cb]	81.2[b]
A. nubica	0.13[c]	9.25[b]	5.6[e]
L.S.D	0.04	0.86	2.8

L.S.D= Least Significant Difference. Means followed by the same letter in a column are not significantly different at P < 0.05 •

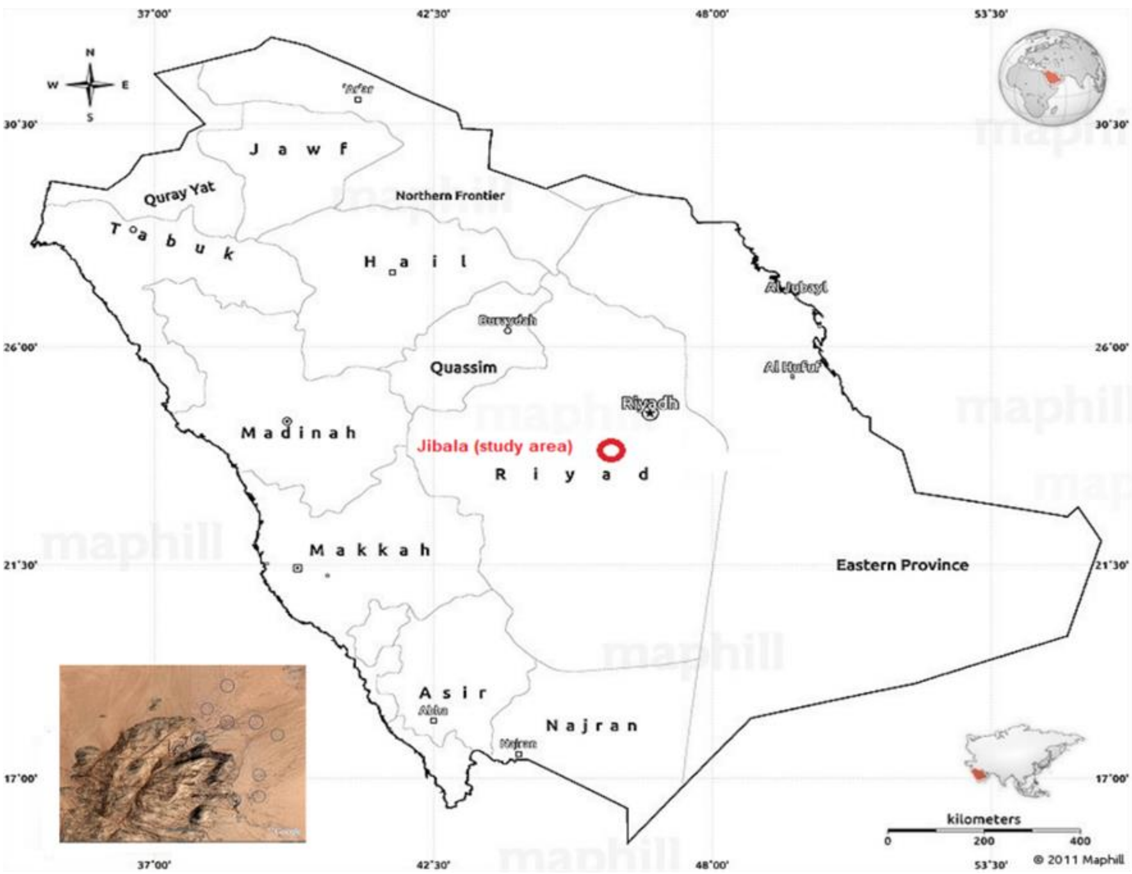

Figure 1. Jibala is located in the Riyadh region of Saudi Arabia (Google Earth).

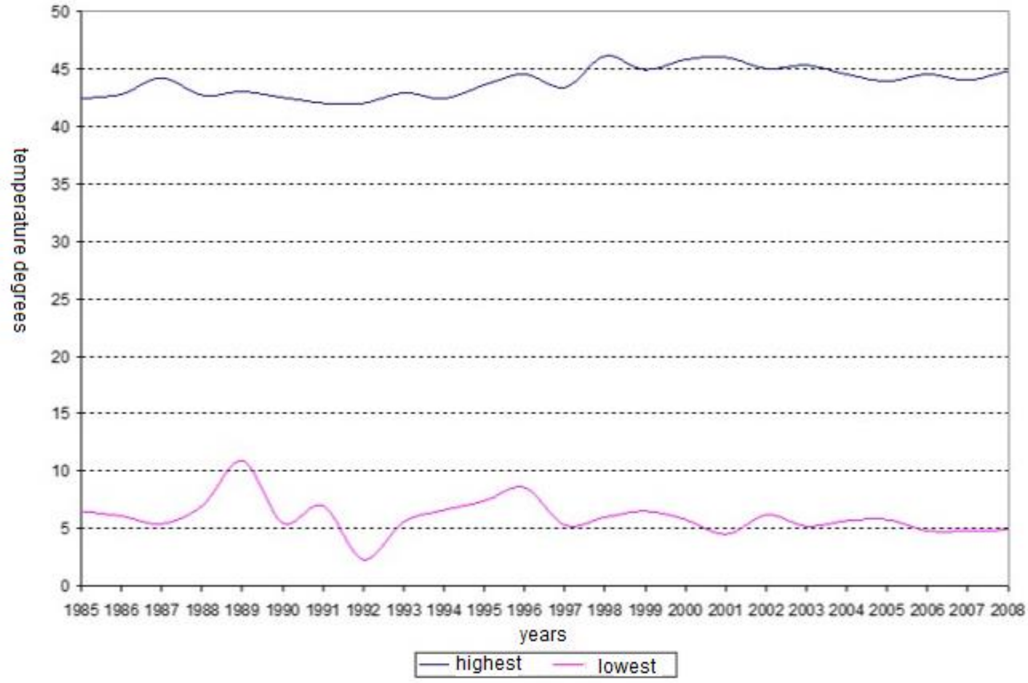

Figure 2. The highest and lowest temperatures from 1985 to 2008 at Buryadh station.

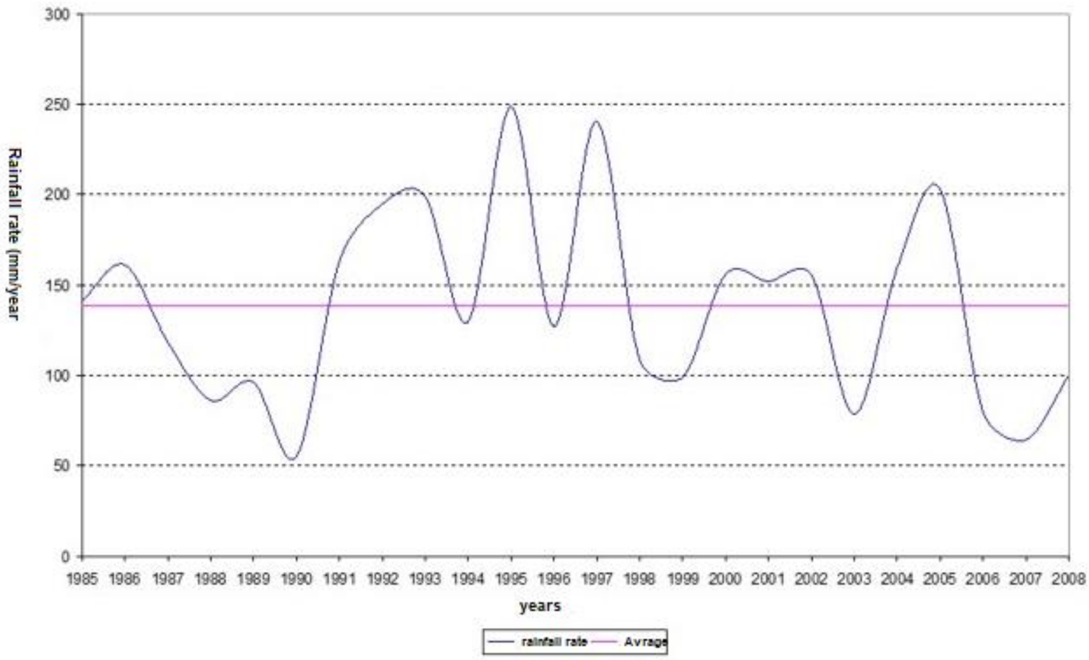

Figure 3. Rainfall rate each year from 1985 to 2008 at Buryadh station.

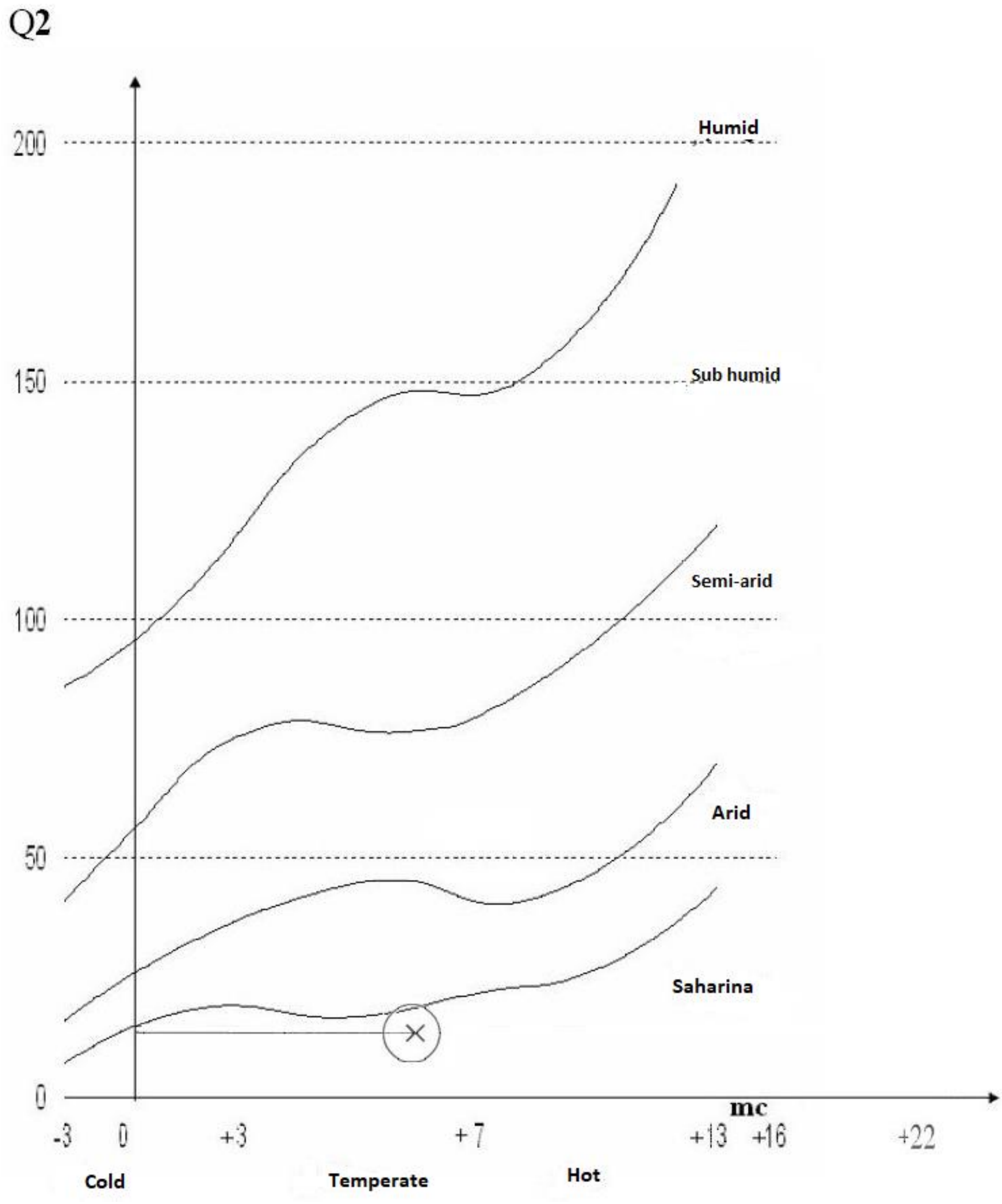

Figure 4. Climate location of Buryadh in (Emberger graph.)

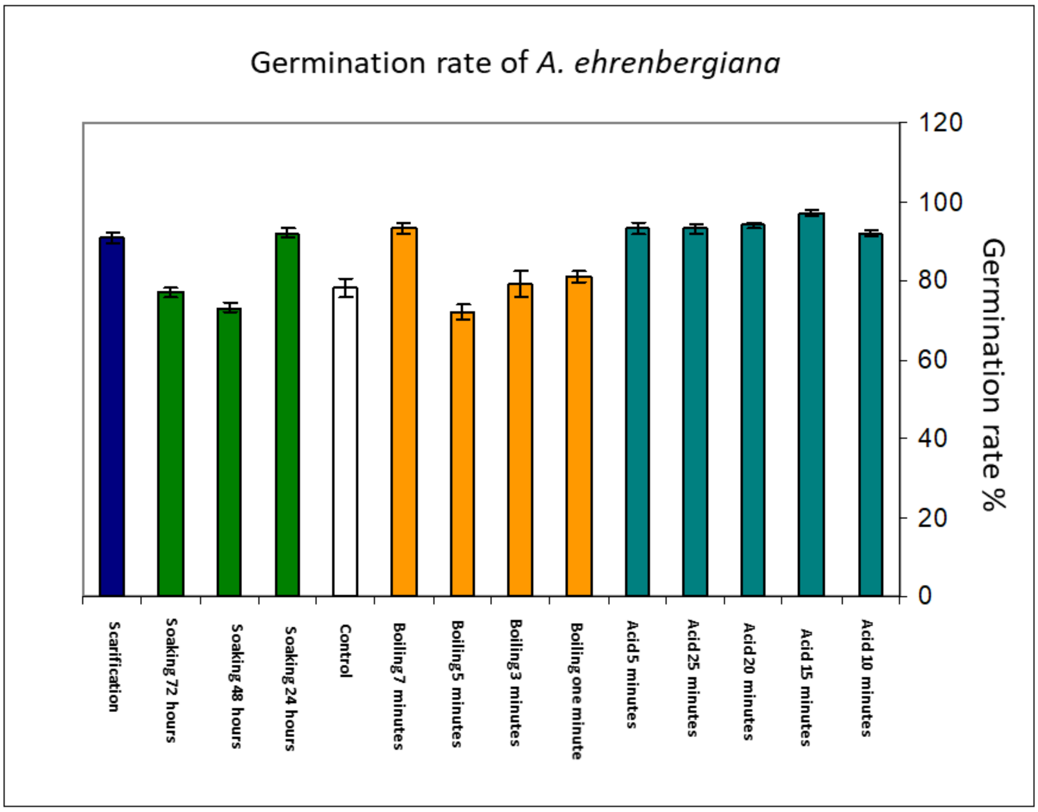

Figure 5. The effect of germination treatments in A. ehrenbergiana.

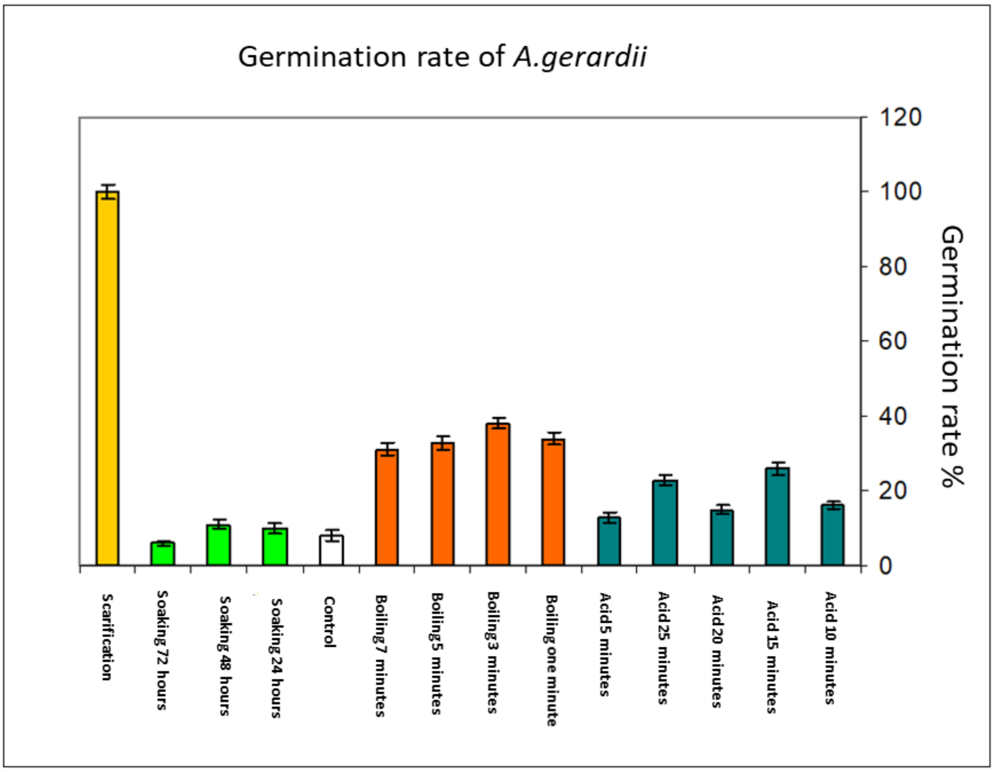

Figure 6. The effect of germination treatments in A. gerardii.

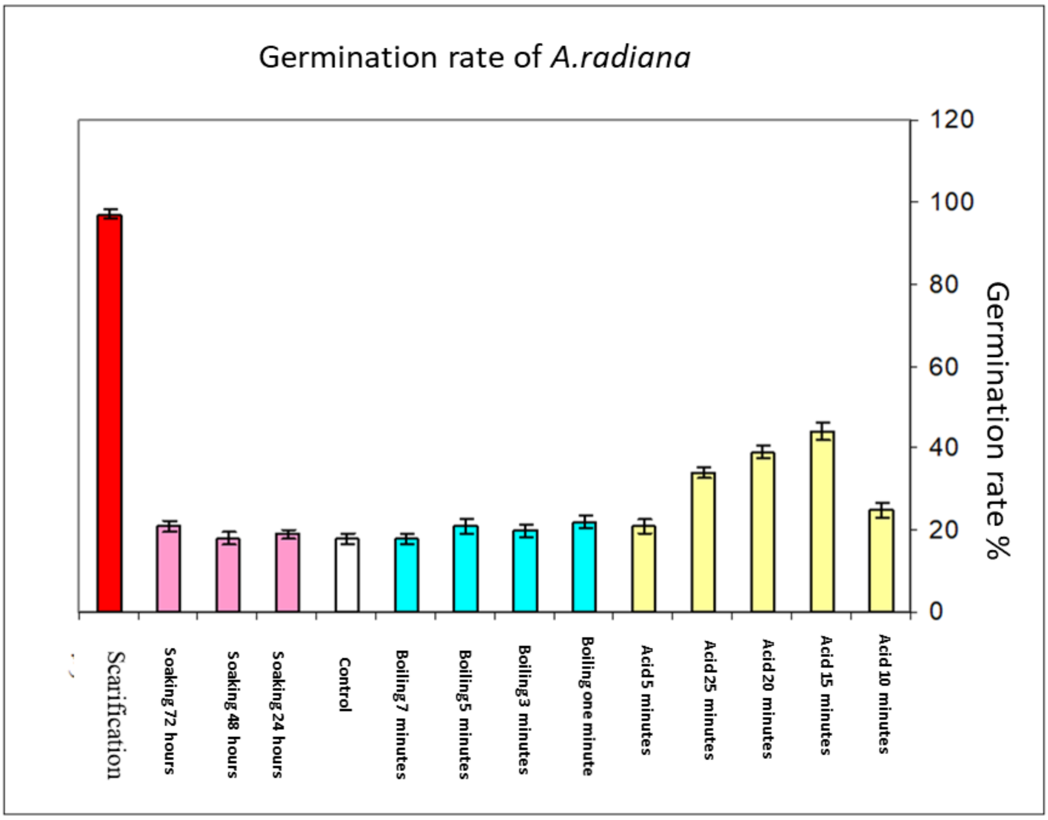

Figure 7. The effect of germination treatments in A. raddiana

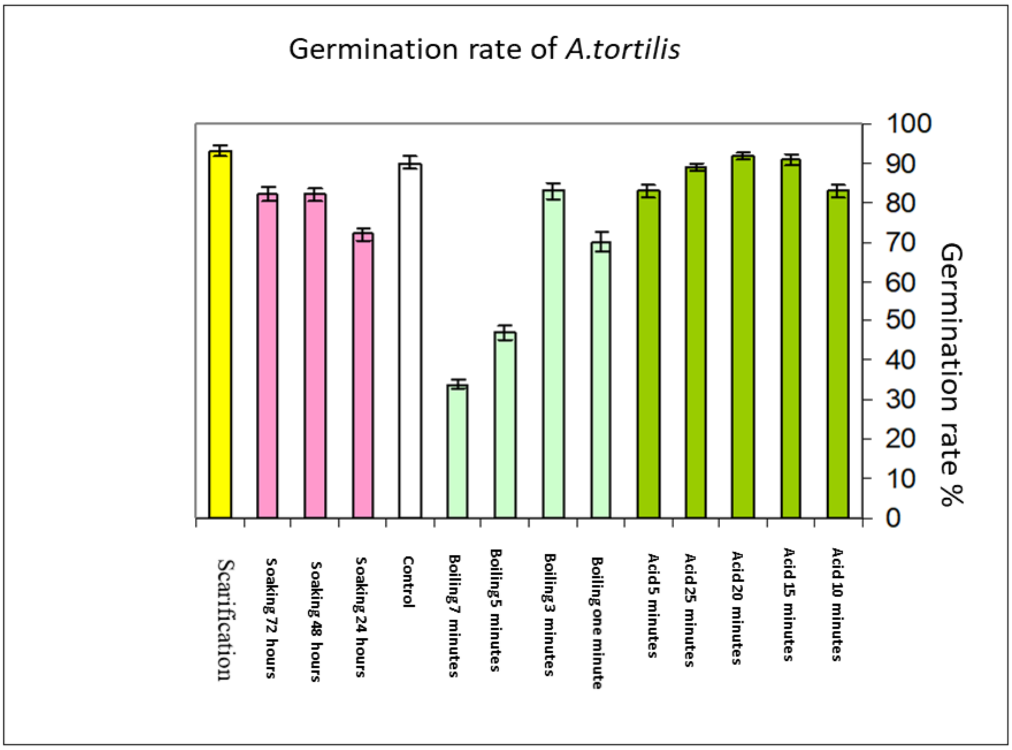

Figure 8. The effect of germination treatments in A. tortilis.

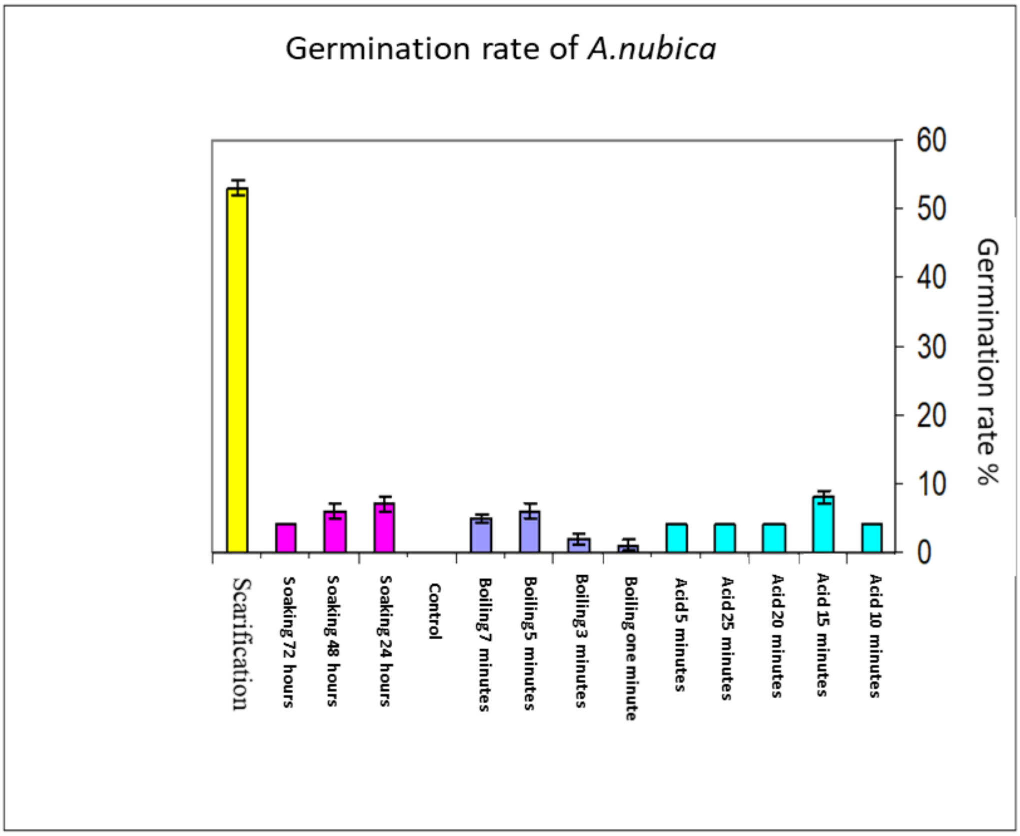

Figure 9. The effect of germination treatments in A. nubica