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Effects of Different Pretreatments on Seed Germination and Early Establishment of the Seedlings of *Juniperus procera* Trees

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Abstract: The present investigation was carried out to study the necessity of artificial regeneration for *Juniperus procera* through applying a number of pretreatments to simulate the germination of seeds and early establishment of their seedlings. The results showed that the untreated, scarified and cold-stratified seeds had germination percentages were greater than those in the other pretreatments. Most juniper seedlings which produced from untreated and treated seeds and transferred to pots emerged their primary leaves from the first week to week 5, from which needles started to develop. By the end of the experiment the proportion of the needles ranged from 19.5% on the seedlings that were produced by seeds extracted from stratified cones to 100% on those that were soaked for 5 minutes in acid. The seedlings grown from the untreated and treated seeds had average heights were significantly different and can be ordered as follows: cold stratification, soaked in acid for 5 and 10 minuets, scarified, soaked in acid for 20 minuets, untreated, soaked in water and cold stratified cones; respectively. Survival percentage of the germinated juniper seedlings in Petri dishes was 37%, while it was 83% for those grown in the greenhouse. Accordingly, we recommend sowing the seeds of *Juniperus procera* after extraction from cones without any pretreatment.

Key words: *Juniperus procera* · Regeneration · Seed germination · Pretreatments · Growth · Natural forests

INTRODUCTION

The natural forests in the southwestern highlands of Saudi Arabia are considered a unique ecosystem in the region. *Juniperus procera* is the most prominent component of vegetation at or above 1600 m elevation [1]. It comprises about 95% of the forest area in this region [2]. These forests provide construction materials and firewood, grazing and beekeeping areas and other benefits mainly for the local inhabitants. They are home to a variety of families, genera and species of living organisms. These forests as a part of the global forest vegetation play a vital role in storing amounts of carbon in its biomass and soils. However, they are suffering from degradation in the present due to many factors. One of the indicators of this degradation is the low capacity of natural regeneration of *Juniperus procera* trees. El-Juhany [3] stated that there are indications of forestland degradation in various parts of the region and mentioned low capacity of natural regeneration of the main forest species as one of the most obvious indications of such degradation.

Aref and El-Juhany [4] suggested that the presence of drought, disturbance caused by increasing recreation activity through forests, over-grazing, fires and the slow nature of juniper growth are the main causes of the decreased natural regeneration. Other studies attributed the lowest capacity of the natural regeneration in juniper forests to biological stresses caused by specific insets damaging juniper cones [5]. While Gardner and Fisher [6] mentioned that human disturbance, grazing pressure and climatic change are the factors that could lead to poor regeneration in the *Juniperus* woodland on the Arabian Peninsula. Other studies also reported on low capacity of

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natural regeneration in the natural forests of Saudi Arabia [4,5,7-10]. Thus it is considered as endangered species that should be given the highest priority for conservation [11, 12]. Overgrazing seems to be the main cause of the problem of low capacity of natural regeneration in these forests. According to the Ministry of Agriculture in Saudi Arabia, "Forests National Work Plan and Strategy (2002) "Overgrazing is a major impediment to the regeneration of the juniper woodlands". Many other authors accused grazing (*e. g*. 13, 14, 15]. The rehabilitation of degraded forest land can be done by facilitating natural regeneration [16]. Fencing to restrict the cattle access from browsing the new seedlings is one of the ways by which natural regeneration can be promoted [17-19]. Also, planting juniper trees in the degraded sites is considered priority toward restoring these natural forests [10]. However, because planting juniper trees has never been practiced in the region, there is some difficulties will encounter rising their new seedlings. The present study aims at evaluating the artificial germination of *Juniperus procera* seeds using different pretreatments and their effects on producing seedlings.

MATERIALS AND METHODS

By the end of 2005, ripe cones of *Juniperus procera* Hochst. Ex. Endl. were collected from trees grown in Riydah reserve in the southwestern region of Saudi Arabia. Seeds were extracted from cones; with a number of cones left without extraction.

Pretreatments of Juniper Seeds: A number of pretreatments were applied in order to enhance germination of juniper seeds in the laboratory and they were as follows:

Scarification: 300 seeds of *Juniperus procera* were divided into three groups of 100 each. These were soaked in concentrated sulphoric acid (98%) for 5, 10 and 20 minutes, respectively. Then the seeds were washed thoroughly under tap water to remove all the acid residuals. Each treated group of 100 seed were distributed into four 9.5 mm Petri dishes (25 seed for each dish) where placed on wetted filter paper that were kept continuously moist with distilled water. The 12 Petri dishes were tightly closed and placed on a table in the laboratory. Other 100 seeds of *Juniperus procera* were scarified using scratching sheets (sandpaper) then treated as those soaked in acid.

All the Petri dishes containing the treated seeds were placed on a table at the room temperature (24°C) for 75 day and. Thereafter, germination percentage for each pretreatment was calculated.

Soaking in Water: 100 seeds f *Juniperus procera* were soaked in tap water at the room temperature for 24 hours. Other seeds *of Juniperus procera* were soaked in water that was boiling for 0.5, 1.0 and 1.5 minute at a rate of 100 seed for each period. The seeds of each pretreatment were distributed into four 9.5 mm Petri dishes (25 seed for each dish) where placed on wetted filter paper in the laboratory and treated in a way similar to that was mentioned above.

Stratification: Seed of *Juniperus procera* were placed in two layers at a rate of 25 seed for each layer alternatively with three layers of sand and sterilized peat moss in a plastic box (20 × 15 × 10 cm). This was repeated for other three boxes then all were placed in the refrigerator at 5°C for 75 day. Similarly, cones of *Juniperus procera* were subjected to cold stratification at the same temperature and duration.

After completing the period of stratification for seeds, they were treated in the laboratory in a way similar to that was done with those in the other pretreatments. While the stratified cones were opened, seeds were obtained, cleaned, then placed in Petri dishes and treated in a way similar to that was mentioned above.

Without Treatment: 100 seed of *Juniperus procera* were washed and placed on dampened filter paper in four 9.5 mm Petri dishes then treated in a way similar to that was mentioned above. After completing the time of each pretreatment, the treated seed were distributed into four 9.5 mm Petri dishes (25 seed for each dish) where placed on wetted filter paper and treated in a way similar to that was mentioned above.

Producing Juniper Seedlings: The seeds that germinated using the aforementioned pretreatments were used to produce seedlings. They were transferred into 20-cm rim plastic pots filled with a mixture of sand and sterilized peat moss at a rate of 2:1 (v/v) and received the normal care in the greenhouse for eight weeks.

The seedlings in the greenhouse were monitored for eight weeks after transferring date. The time of emerging the primary leaves and needles on the seedlings was determined. The height of each seedling was measured and recorded.

Survival percentage of the seedlings germinated in the lab and those continue to grow after transferring to pots were calculated as an average of the germination percentages in all the pretreatments and, an average of the percentages of the growing number seedlings in greenhouse.

Statistical Design and Analysis: Randomized Complete Design was use in carrying out the experiment of seed germination in the laboratory and producing the seedlings in the greenhouse. The obtained data was analyzed using the analysis of variance procedure (ANOVA) through SAS computer programme [20]. The means of treatments were distinguished using Duncan's Multiple Range Test at $P \geq 0.5$ [21].

RESULTS

Germination of Juniper Seeds: The germination experiment lasted 10 weeks. There was no any germination at all in the first two weeks. By the end of the third week, the stratified seeds had the greatest germination percentage (14%) comparing with 7, 6 and 3% for those soaked in acid for 20 minutes, scratched and untreated, respectively (P=0,0002). By the end of the week four, the scratched seeds had the greatest germination percentage (38%) then, the stratified seeds (31%) and the untreated seeds (27%) (P=0.0001). The germination percentages of the other pretreated seeds were less (Table 1).

By the end of the fifth week, the germination percentages of both the scratched and untreated seeds were 60%, while that of the stratified seeds was 46%, then the other treated seeds. In the beginning of that week, there was a start of germination in the stratified juniper cones estimated at 5% (P< 0.0001) (Table 1).

This trend continued more or less until the beginning of the seventh week. By the eighth week, the means of the germination percentages were 74, 70, 59, 43, 42, 32, 21 and 14% for the untreated, scratched, stratified, soaked in acid for 20 minutes, soaked in water, soaked in acid for 10 minutes, stratified cones and soaked in acid for 5 minutes, respectively (P=0.0009). This order continued until the beginning of the ninth week with minor increases, except the percentage of the germination of the seeds that were extracted from the stratified cones which duped (P=0.0026) (Table 1).

By the end of the tenth week, there was constancy in the germination percentages with a variation in the order of the pretreatments as the germination of the stratified seeds ceases. Therefore, the order became as follows: 76, 71, 48, 44, 40 and 17% for the germination percentage of the untreated, scratched, soaked in water, soaked in acid for 20, 10 and 5 minutes, respectively (P=0,0073) (Table 1).

Producing Juniper Seedlings: After transferring the germinated juniper seeds in Petri dishes by the aid of the pretreatment used (or without pretreatment) to the pots in the greenhouse, their leaf development and heights growth were measured weekly from the third week after transferring.

Growth of the Leaves: After one week of transferring the germinated seeds to the pots, seed leaves (primary leaves) occurred on all the seedlings produced from the different pretreatments applied on the seeds. The exception of this is the seedlings produced from the seeds that were extracted from stratified cones, where their seed leaves occurred by the second week.

By the end of the fifth week, the primary leaves predominate all the seedlings at a rate of 100%, except for the seedlings produced from stratified and scratched seeds, in which the primary leaves occurred at a rate of 10.4 and 1.6%, respectively (Table 2).

By the end of the sixth week, all the seedlings beard needles at a rate ranged between 17.9 and 57.1%; with the seedlings produced from scarified seeds had the greatest value. The percentage of the emerged needles increased by the seventh week and ranged between 45.2 and 56.3%; with no needles occurred at all on the seedlings produced from the seeds that were extracted from stratified cones (Table 2). These seedlings started to bear needles by the eighth week and at rate of 19.5%. At that date, all the seedlings produced from seeds soaked in acid for 5 minutes had needles, while 93.7, 85.7, 82% of those produced from scratched, soaking in water and untreated had needles (Table 2). The other three groups (*i. e*. soaked in acid for 10 and 20 minutes and stratified seeds) had more or less close values which were lower than those produced from the scratched, soaking in water and untreated seeds (Table 2).

Height Growth: After three weeks of transferring the germinated seeds to the pots, the seedlings produced from the seeds that were treated with stratification started to grow and had the greatest mean height (0.035 cm), then that of those treated with scarification (0.03 cm) (P<0.0001). By the end of the fourth week, the heights of the seedlings produced from the seeds that were stratified, scratched, untreated, soaked in acid for

Table 1: Average germination percentage of *Juniperus procera* seeds from week 3 to week 10 after sowing

	Weeks after sowing							
Pretreatment	3rd	4th	5th	6th	7th	8th	9th	10th
Soaking in acid for 5 min.	*0b	4c	7c	11d	14c	15c	16b	17c
Soaking in acid for 10 min.	0b	1c	13cb	22cd	32bc	36bc	36b	40bc
Soaking in acid for 20 min.	7b	12bc	28b	38bc	43abc	44abc	44ab	45abc
Scarification	6b	38a	60a	68a	70a	71ab	71a	71ab
Soaking in water	0b	3c	14cb	26cd	42abc	43abc	47ab	48abc
Cold stratification	14a	31a	46a	50ab	59ab	62ab	---	---
Cold stratification (cones)	0b	0c	0c	5d	21c	41abc	---	---
Without treatment	3b	27ab	61a	69a	74a	75a	75a	76a

*Means followed by the same superscript letters within each column are not statistically different at $P \leq 0.05$

Table 2: Percentage of different leaf types emerged on the seedlings of *Juniperus procera* grown from seeds subjected to pretreatments from week 3 to week 8 after transplanting to pots in the greenhouse

	Week											
	5th			6th			7th			8th		
	Leaf type											
Pretreatment	*a	b	c	a	b	c	a	b	c	a	b	c
Soaking in acid for 5 minutes	100.0	0.0	0.0	63.6	36.4	0.0	54.5	45.5	0.0	0.0	100.0	0.0
Soaking in acid for 10 minutes	100.0	0.0	0.0	82.1	17.9	0.0	53.6	46.4	0.0	17.9	78.6	3.6
Soaking in acid for 20 minutes	100.0	0.0	0.0	75.0	25.0	0.0	43.8	56.3	0.0	15.6	78.1	6.3
Untreated	100.0	0.0	0.0	67.2	31.1	1.6	27.9	68.9	3.3	11.5	82.0	6.6
Scarification	98.4	1.6	0.0	41.3	57.1	1.6	11.1	85.7	3.2	3.2	93.7	3.2
Soaking in water, 24 h	100.0	0.0	0.0	73.8	26.2	0.0	54.8	45.2	0.0	9.5	85.7	4.8
Cold stratification (seed)	89.6	10.4	0.0	55.2	44.0	0.8	23.2	74.4	2.4	20.0	75.2	4.8
Cold stratification (cones)	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	80.5	19.5	0.0

*a: primary, b: needle and c: dead leaves

Table 3: Effects of germination pretreatments on the growth of stem height (cm seedling^{-1}) of *Juniperus procera* seedlings from week 3 to week 8 after transferring to pots in the greenhouse

	Week (after transferring to pots)					
Pretreatment	3rd	4th	5th	6th	7th	8th
Soaking in acid for 5 min.	*0b	0.33bcd	0.73bc	1.25bc	1.82a	2.18ab
Soaking in acid for 10 min.	0b	0.06cd	0.58c	0.98c	1.76a	2.12ab
Soaking in acid for 20 min.	0b	0.23cd	0.72bc	1.20c	1.73a	1.97ab
Scarification	0.03b	0.70ab	1.31a	1.71a	1.95a	2.02ab
Soaking in water	0b	0.10cd	0.49c	0.96c	1.61a	1.90b
Cold stratification	0.35a	0.87c	1.46a	1.68ab	2.04a	2.29a
Cold stratification (cones)	0b	0d	0d	0.15d	0.8b	1.84b
Without treatment	0 b	0.46bc	1.06ab	1.40abc	1.80a	1.94b

*Means followed by the same superscript letters within each column are not statistically different at P=0.05

5 minutes, soaked in acid for 20 minutes, soaked in water and soaked in acid for 10 minutes were 0.87, 0.70, 0.46, 0.33, 0.23, 0.10 and 0.06 cm, respectively and were significantly different (P<0.0001) (Table 3).

This trend continued until the beginning of the sixth week with increases in the heights values and significant differences between them (P<0.0001) (Table 3).

By the seventh week, the seeds that were extracted from stratified cones started to emerge seedlings. The heights of the seedlings were 1.71, 1.68, 1.40, 1.24, 1.20, 0.97, 0,96 and 0.15 cm for the seedlings produced from scratched, stratified, untreated, soaked in acid for 5, 20, 10 minutes, soaked in water and those grown from seeds extracted from stratified cones, respectively and were significantly different (P<0.0001) (Table 3).

By the eighth week, the order of the means of the seedlings heights changed and their values increased. They were 2.04, 1.95, 1.82, 1.80, 1.76, 1.73, 1.61 and 0.80 cm for the seedlings produced from the seeds that were stratified, scratched, soaked in acid for 5 minutes, untreated, soaked in acid for 10 and 20 minutes, soaked in water and those grown from seeds extracted from stratified cones, respectively and were significantly different (P<0.0001) (Table 3).

By the end of the eighth week, the means of the seedling heights were 2.29, 2.18, 2.12, 2.02, 1.97, 1.94, 1.90 and 1.84 cm for those produced from the seeds that were stratified, soaked in acid for 5 and 10 minutes, scratched, soaked in acid for 20 minutes, untreated, soaked in water and those grown from seeds extracted from stratified cones, respectively and were significantly different (P=0.0002) (Table 3).

The seeds that were soaked in the boiled water for 0.5, 1.0 and 1.5 minutes did not give any germination.

Evaluation of Seed Germination and Seedling Growth: The survival percentages of the seedlings resulted from treating the seeds in Petri dishes in the laboratory and in the greenhouse were calculated at the end of the experiment. The survival percentage of the germinated juniper seeds in the laboratory as an average of the germination percentages in all the pretreatments was 37.3%. Similarly, the survival percentage of the seedlings grown in the greenhouse was 82.4%.

DISCUSSION

Regeneration of Juniper Trees: Facilitating natural regeneration can be achieved through measures such as protection from chronic disturbance, site stabilization or water management. Regarding the juniper forests of the southwest Saudi Arabia, understanding the growth nature of juniper trees and their regeneration is of great importance when thinking in remedying and improving these forests. Bishaw [22] asserted that conservation of the natural forests should be given adequate attention and research in these forests should focus in improving natural regeneration of the various species and conservation of biodiversity. In order to overcome the problem of poor natural regeneration of juniper trees, it is necessary to reforest the deteriorated areas with trees grown from local seeds. This can not be achieved without germinating juniper seeds and raising healthy seedlings [4]. They concluded with improving regeneration of *Juniperus procera* trees in southwest region of Saudi Arabia is possible through collecting cones from vigour trees, extracting seeds and planting them in the nursery then transferring the produced seedlings to the natural forest.

Seed Dormancy: Seeds of many juniper species show delayed germination because of dormant embryos or hard seed coats [23]. Many plants have dormant seeds as a biological mechanism to ensure that seeds will germinate at a time and under conditions that are favorable for the growth and survival of the next generation [24]. There are two types of dormancy: exogenous (seed coat dormancy) and endogenous (embryo dormancy). Some species have hard seed coats preventing imbibition of water and the exchanges of gases. Without imbibition and gas exchange, germination would be impossible [25]. Physical seed coat dormancy occurs frequently in species adapted to alternating dry and wet seasons, including leguminous genera [26]. Physical seedcoat dormancy occurs also in some members of the family *Cupressaceae* (*Juniperus procera*) [27]. Fordham and Spraker [28] mentioned that seeds of some gymnosperms (for example, *Juniperus*) are prevented from germinating by impermeable seed coats that hinder the admission of water, as well as by immature embryos. Such seeds are said to be doubly dormant, since two conditions must be overcome before germination can take place. In nature, it takes two or more years for these seeds to germinate. Low germination percentages and slow germination, with germination sometimes being delayed more than 2 years in juniper, are not unusual, however. These problems result from a combination of chemical factors in the embryo and physical factors, such as the thick hard outer layer of the two-layered seedcoat [29, 30]. Broom [18] stated that juniper tree can be difficult to propagate from seed and is slow growing which, when coupled with its susceptibility to browsing, can make establishment difficult.

Seed Germination: In the present study, a number of pretreatment were used to enhance the germination of juniper seeds. The cold-stratified seeds for 75 days started to germinate after three weeks of applying the treatment and, their germination percentage increased steadily from 14% at week three to 62% at week eight. Albrecht [31] found that seed dormancy of *Juniperus procera* was effectively broken by moist chilling in sand at 3°C for 60 days. Using stratification in damp sand at 3°C for 60 days for mature *Juniperus procera* seed resulted in germination rate of 60-70% within 25-80 days [32]. Other studies found that increased germination capacity of juniper seeds as a result of stratifying them [33, 28, 34, 35, 36, 18, 37]. However, the numerous recommendations of using stratification as a pretreatment for breaking the dormancy of juniper seeds varies in temperatures, duration and if it applied alone or after other pretreatments.

Fordham and Spraker [28] postulated that stratification now is interpreted as any process used to encourage germination of dormant seeds that require pretreatment by time and temperature. It tends to hasten and synchronize germination of most gymnosperm seeds, even those that exhibit no dormancy.

The other well known pretreatment for breaking the physical dormancy of juniper seeds is scarification either by soaking the seeds in acid (chemical scarification) or scratching them using sandpapers (mechanical scarification). In the present study, soaking *Juniperus procera* seeds in concentrated sulphoric acid for 20 minutes resulted in germination percentage reached 45% after 10 weeks of sowing date, while scarified seeds using sandpapers resulted in germination percentage reached 71% within the same period. This result concurs with other previous results or recommendations (33, 28, 38, 39 34, 40, 32, 41]. Soaking the seeds in acid for breaking the dormancy also varies in duration and if it applied alone or after other pretreatments.

Soaking the seeds in water is an alternative pretreatment for breaking physical dormancy. In this investigation the seeds that were soaked in tap water for 24 hours caused seed germination was 48% which was similar to that of soaking the seeds in sulphoric acid for 20 minutes. Similar results were reported by Bean [42], Hines and Eckman [38]. This pretreatment is reported to be employed either using tap water or hot water and it varies in its duration.

Cold stratification of cones was tested for the first time in the present study resembling the natural regeneration of *Juniperus procera* trees in the forest, where the ripe cones drop from on the ground and germinate latter on after a period of stratification under letterfall and give the seedlings that are seen under trees. The result obtained in the present study are encouraging as the seeds that were extracted from the cold-stratified cones gave a germination percentage was 41% after 6 weeks.

Emerging juniper seedlings naturally in the forest needs to be studied to know how the process is achieved naturally by means of find out wither the fruits of the current season or that of the previous one that are fall down and, how much time pass to germinate and under what environmental conditions. Broome [18] reported that germination of juniper seeds took a minimum of three months from sowing date following a 15 month stratification period during which the berries were buried in a 2:1 mixture of grit and peat. In order to break dormancy, she recommended removing the seeds from the berries and subjecting them to a long cool–moist treatment. In other words, she mentioned that direct sowing of berries in the field is not recommended. Buttoud and Yunusova [17] reported that the first efforts of artificial regeneration were made for Artcha (*Juniper procera*) forests in the south of Kyrgyzstan, but plantations with berries failed.

There are a number of reports on the positive effects of animals on natural regeneration of juniper trees. Birds are considered to be important dispersal agents for juniper. The fruit surrounding the seed is thought to contain a germination inhibitor; when the fruit is broken down during the acid digestion in the bird's gut, the chances of the defecated seed germinating is thought to increase [43]. Other researchers reported on the positive role of animals as important vectors for seed dissemination and germination of juniper [28, 44]. In the forests of the southwest Saudi Arabia, the role of animals in natural regeneration of juniper trees is not known. Therefore, we assumed that the limited numbers of seedlings that emerge under juniper trees in these forests germinate after merely natural stratification. Lawson [35] stated that seeds of *Juniperus virginiana* L. that pass through animal digestive tracts and those that remain on the ground beneath the trees may germinate during the first or second spring. Thus, research regarding the role for animals in this natural regeneration process in juniper forests of Saudi Arabia is needed.

Having discussed the results of the pretreatments used to break the dormancy of juniper seeds in the present study and presented some other relevant results, however we found that sowing juniper seeds without any pretreatment resulted in germination accounted for 76% that was higher than all those of the other treated seeds.

Similar result was obtained by Aref and El-Juhany [4] who reported that the germination percentage of juniper seeds was 80% in Petri dishes containing absorptive paper and maintained wet and tightly closed for ten days. Other researchers reported that pretreatment of seeds is not necessary and they can be sown directly in seed beds or containers [38, 45].

Seedling Growth: After seven weeks of transferring the germinated seeds to the pots, all had needles at rates ranged between 45.2% (for those grown from seeds that were soaked in tap water) and 85.7% (for those grown from stratified seeds). Until that time, the seedlings grown from seeds that were extracted from stratified cones did not have needles. By the end of the week eight, all the seedlings grown from the seeds that were soaked in sulphoric acid for five minutes had needles followed by the others in the order was as follows: the seedling grown from seeds that were scarified, soaking in tap water, untreated, soaking in sulphoric acid for 10 and 20 minutes then, stratified ones. 19% only of the seedlings grown from the seeds that were extracted from stratified cones had needles after eight weeks. The importance of foliage for a plant seedling is to give it photosynthetic surface that enable it to capture the light and take over in assimilate production to meat the following biochemical processes. Success of seedling production depends on germination capacity, escaping from damping off, survivorship and increase in size.

Height growth of *Juniperus procera* seedlings was affected by the pretreatments applied on the seeds. Five groups of the grown seedlings had average heights were not significantly different and they were produced from seeds that were stratified, scarified and soaked in acid (for 5, 10 and 20 minutes). The average heights of these were grater than those of the seedlings grown for seeds that were soaked in water, untreated and those that were extracted from stratified cones. Aref and El-Juhany [4] mentioned that stem height and diameter of *Juniperus procera* seedlings reached 86.75 and 1.12 cm after two years since planting date, with relative growth rates were 0.0205 and 0.0243 cm cm^{-1} $month^{-1}$, respectively. Herzog [46] asserted that juniper seedlings in Yemen juniper stands are growing very slowly, a few centimeters a year only. This may be true under natural conditions. Noble [39] asserted that the seedlings of Rocky Mountain juniper are reported to reach a height of 30 cm in 8 years in northern New Mexico and Arizona. Their growth is more rapid in nurseries, where they often reach 15 cm or more in 3 years. El-Juhany *et al*. [10] found relative growth rates of planted and naturally grown *Juniperus procera* seedlings in the natural forests of the southwest Saudi Arabia were 0.021 and 0.019 cm cm $month^{-1}$ after 11 months. The lowest values of height growth of juniper seedlings that were presented by some authors may a result of the known slow growth of juniper or due to the development strategy of this species. For instance, first-year seedlings begin developing a long fibrous root system, often at the expense of top growth [47]. Generally, the behavior of the seedling following germination can be intimately tied to seed characteristics, including dispersibility, size and dormancy [48].

In the present study, survival percentage of the juniper seedlings that were produced by sowing the treated and untreated juniper seeds in Petri dishes was 37% and for those growing for eight weeks after transferring to the greenhouse was 83%. Aref and El-Juhany [4] reported on survival percentage of the juniper seedlings that were planted in the forest was 98% after two years. Moreover, El-Juhany *et al*. [10] found survival percentage of juniper seedlings planted in the natural forests of the southwest Saudi Arabia also was 82%.after 11 moths.

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