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An investigation into the effect of different levels of stockosorb on the establishment and vegetative characteristics of *Tamarix aphylla* and *Eucaliptus camadulensis* seedlings in a light-textured (sandy) soils

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Abstract

This experiment was done to compare the effect of different levels of superabsorbent on the establishment and characteristics of *Tamarix aphylla* and *Eucaliptus camadulensis* seedlings in the Agricultural and Natural Resource Research Center of Sistan. The experiments were conducted in light-textured soil. The investigated treatments included: The main factor including irrigation treatment at two water depletion levels of 25% and 75%.. The secondary factor, i.e. superabsorbent treatment, was considered at four levels of 0, 50, 100, and 200 grams for each seedling. The secondary factor included two *T. aphylla* and *E. camadulensis* species, which was done in three replications in a split-split plot design. The maximum establishment belonged to E. camadulensis, under water depletion of 25% and the application of 100 grams of superabsorbent. With respect to *T. aphylla*, water depletion of 25% and the application of 100 grams of superabsorbent accounted for the largest percentage of establishment. The application of the superabsorbent on a light soil positively affected the height of the plant, collar and canopy cover diameter, and the weight of aerial organs and root. In that, these values were higher in E. camadulensis. After collecting statistics, data were analyzed with MSTATC and Excel.

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Introduction

Water resources are limited in arid and semiarid ecosystems and the plants within these regions are under drought stress (Kramer and Boyer, 1995). In terms of climate, Iran is in an arid part of the world, where at most 35% of its area has more than 250 mm annual precipitation. This level is less than 100 mm, on average, in the most parts of the country. With respect to the water resource limitations in Iran, reducing water consumption is absolutely essential. With providing proper management and employing advanced practices by conserving soil moisture, improving water infiltration into the soil, and enhancing water use, we can take an important step towards the effective utilization of limited water resources (Karimi, 2001). Some materials such as vegetative residues, animal manure, composite manure, and superabsorbent composites can hold different amounts of water and increase water storage capacity of the soil (Sharafa, 1987). The application of such modifiers, as superabsorbent polymers to maintain soil moisture level and to increase water storage capacity of the soil, are numbered among the effective instituted measures for performance improvement. After the absorption and due to the dryness of the area, water stored in the polymer is gradually released, making the soil moist and needless of re-irrigation for a long period (Kochakzadeh *et al.*, 2000). Superabsorbent materials, due to their capability in storing moisture in the soil for a long time, are capable of reducing water consumption in light soils. This feature has led to successful application of these materials in agriculture and reforestation (Chirino *et al.*, 2011; Gunez, 2007). In a study, Poormeidani and Khakdamani (2005) studied the application of aquasorb polymer on the irrigation of *Pinus eldarica*, Olea europea, and *Atriplex canescens* in Hossein Abad Station of Sand Stabilization in Qom Province. Applying analysis of variance on data and comparing the mean of different levels of the first factor with the aid of Dunken method showed a significant difference (at probability level of 1%) between the investigated species, in terms of survivability and freshness of the seedlings. *Atriplex canescens, Olea europea,* and *Pinus eldarica*, in order, obtained the highest survivability scores in six months after the plantation. In addition, a significant difference was observed at probability level of 1% between different levels of polymer application in all traits, except soil moisture at the depth of 50 cm before and after irrigation. The application of different levels of polymer had different effects on the investigated traits. In all traits, zero polymer level and control (with normal irrigation) treatments were divided into separate groups. The second level of polymer was in the same group with control treatment. In general, using polymer when planting the given seedlings can be recommended for reducing the amount and number of irrigation, without affecting the survivability. Objective of this study was survey effect of different levels of superabsorbent on the establishment and characteristics of *T. aphylla* and *E. camadulensis* seedlings.

Materials and methods

Location specification

This study was done in Agricultural and Natural Resources Research Center in Zahak, located at 30°54'E longitude, 61°41'N latitude, and 438 meters above sea level. The investigated soil texture was light within the climatic range. Based on the results obtained from the weather station in Zahak, the average annual precipitation was 59 mm in the past 23 years, of which 13.4 mm, 2.7 mm, 0.03 mm, and 3.56 mm had occurred in winter, spring, summer, and fall, respectively.

Experimental design, treatments and plantation

In this study, a split-plot statistical design was used in randomized complete block design with three replications. The desired experimental condition included a flat, slope-less ground with the seedling spaced 2*2 meters from each other. The investigated treatments included: The main factor including irrigation treatment at two water depletion levels of 25% and 75%.. The soil moisture was measured by means of a TDR device. The secondary factor, i.e.

superabsorbent treatment, was considered at four levels of 0, 50, 100, and 200 grams for each seedling. In this study, Stockosorb was used as superabsorbent. The secondary factor included two *T. aphylla* and *E. camadulensis* species. In each treatment of each replication, 4 seedlings were planted. The seedlings were supplied by the nursery of Department of Natural Resources of Zahak. Therefore, the minimum stress was imposed by transferring the seedlings from the production site to the planting site. The seedlings are perfectly in compliance with the region's conditions.

The plantation was done at the beginning of Isfand (in Iranian calendar from 20the February to 20th March) by digging 60*60*50 cm^3 holes. Then, 10 kg of the removed soil was mixed with predetermined amount of polymer and poured around the seedlings' roots. Irrigation was done based on predetermined treatments. The crown and collar diameters were measured with 0.1 cm accuracy. To weigh dried samples, a digital scale with readability to 0.01 gram was used. Three soil samples were prepared from the experiment site, and their physical and chemical characteristics were then measured. The obtained data were analyzed in split-split plot design, using MSTATC and Excel.

Findings and discussion

Physical and chemical characteristics of the soil: Before the plantation, three samples from the experiment site were prepared. Prior to the experiments, it was found that the soil's physical and chemical characteristics were in compliance with Table 1. Consequently, it was concluded that the soil's chemical and physical features were not limiting the growth and the establishment of the seedlings of *T. aphylla* and *E. camadulensis*.

Table 1. Physical and chemical characteristics of the soil.

	texture	Sand %	Silt %	Clay %	Ec	pH	O.C %
Sample 1	sandy	90	6	4	2.3	8.7	0.06
Sample 2	sandy	91	4	5	2.4	8.7	0.06
Sample 3	sandy	92	5	3	2.2	8.6	0.06

Survivability and Establishment

The lowest survivability was six month after the plantation of: *E. camadulensis*, under 75% water depletion scenario and free of superabsorbent (53.8%); and *T. aphylla*, under 75% water depletion scenario and the application of 200 grams of superabsorbent (66%). The highest survivability belonged to: E. camadulensis, under 25% water depletion scenario and the application of 50 grams of superabsorbent (100%); and *T. aphylla*, under 75% water depletion scenario and the application of 100 grams of superabsorbent (100%). Statistical analysis also did not show any significant correlation between different irrigation and superabsorbent levels; however, the survivability was higher under 25% water depletion scenario and higher absorbent levels. Survivability between *T. aphylla* and *E. camadulensis* was significant at confidence level of 99%, in that the survivability of *E. camadelunsis* (91%) was greater than that of *T. aphylla* (82%).

The survivability of the plants, 18 months after plantation, was considered equal to the establishment. The lowest establishment rate belonged to *T. aphylla* (25%), under 75% water depletion scenario and free of superabsorbent. The maximum establishment was related to *E. camadulensis* (100%), under water depletion of 25% and the application of 100 grams of superabsorbent.

Statistical analysis demonstrated a significant difference between different irrigation levels at confidence level of 95%. However, the difference between different levels of superabsorbent was not significant, survivability was higher at greater levels of superabsorbent. Establishment level (%) between

T. aphylla and *E. camadulensis* was significant at confidence level of 99%, in that the establishment of *E. camadelunsis* (87.5%) was greater than that of *T. aphylla* (75%).

In a study in Yuan Province in China, Ma and Nelles (2004) showed that the establishment rate of seedlings was 70%, on average, in the regions, where hydrogel modified soil was poured around the plants' roots, 19 months after the plantation; while, this rate reached 20% under control treatment.

In another project in Uganda, four vast deserted and destructed areas were prepared for cultivation. The administered treatments included adding 10 and 40 grams of hydrogel to the soil used for filing the holes around the seedlings. Results from this first time study in Africa showed a positive and significant effect of the application of the both levels of superabsorbent on the establishment rate and biomass of aerial organs of 9 tree species under investigation (Lawrence, 2009).

Bandak (2010) in a study investigated the effect of two types of superabsorbent, namely A200 and Stockosorb, on vegetative characteristics of *Atriplex canescens*, planted in a pot and kept in greenhouse. The hydrogel levels used in this study were 0.6, 1.8, and 3.2 grams for per kilogram of soil. Irrigation was done at two levels, including field capacity and wilting point. Results showed that the two superabsorbent materials used in this study had positive effect on the investigated characteristics, and facilitated and enhanced the establishment and survivability of *Atriplex canescens* under water shortage and drought stress.

Seedling height

The lowest height (69 cm), six months after the plantation, belonged to *T. aphylla*, under 75% water depletion scenario and free of superabsorbent. The maximum height (107.5 cm) belonged to *E. camadulensis*, under 25% water depletion scenario and the application of 100 grams of superabsorbent.

Statistical analysis also showed a significant difference between different irrigation levels at confidence level of 95%. the heights under 25% and 75% water depletion scenarios were measured equal to 99 cm and 83 cm. There was a significant difference between different levels of superabsorbent at confidence level of 99%. It also was found that higher level of superabsorbent is correlated with greater plant height. There was not any significant difference between the heights of *T. aphylla* and *E. camadulensis*, six months after the plantation; however, *E. camadulensis* was taller than *T. aphylla* (92.6 cm versus 89.4 cm).

Eighteenth months after the plantation, the lowest height (151 cm) belonged to the seedlings of *E. camadulensis*, under 75% water depletion scenario and free of superabsorbent. In addition, the average height of *E. camadulensis* was 154 cm, under 75% water depletion scenario and the application of 50 grams of superabsorbent. The maximum height (223.3 cm) belonged to *E. camadulensis*, under 25% water depletion scenario and the application of 100 grams of superabsorbent.

Statistical analysis also showed a significant difference between different irrigation levels at confidence level of 99%. The heights under 25% and 75% water depletion scenarios were measured equal to 209.5 cm and 173.4 cm, respectively. There was a significant difference between different levels of superabsorbent at confidence level of 99%. It also was found that higher level of superabsorbent is correlated with greater plant height. Although, *T. aphylla* was taller than *E. camadulensis* (193 cm versus 189 cm), there was no significant different between the heights of *T. aphylla* and *E. camadulensis*, six months after teh plantation.

Agaba (2010) studied the effect of adding hydrogel to different soils on the water accessibility to plant and survivability of the trees under drought condition. They reported Grevillea robusta seedlings, which were under drought stress and treated with 0.2% and

0.4% superabsorbents, showed more establishment, at suitable level, to control treatment.

Collar diameter and canopy coverage

The smallest collar size, 18 months after the plantation, belonged to *E. camadulensis* (19.4 mm), under 75% water depletion scenario and free of superabsorbent. In addition, under 75% water depletion scenario and the application of 50 grams of superabsorbent, collar diameter, equal to 22 mm, was registered for *E. camadulensis*. The biggest collar diameter of the seedlings belonged to *T. aphylla*, under water depletion of 25% and the application of 100 and 200 grams of superabsorbent (41 and 43 mm, respectively).

Statistical analysis also showed a significant difference between different levels of irrigation and superabsorbent with different species at confidence level of 99% (Table 2). The average collar diameter, under 25% water depletion scenario was 34.4 mm. In contrast, it was measured equal to 27 mm under 75% water depletion scenario. In addition, collar diameter was bigger at greater levels of superabsorbent (Table 2). Collar diameter was significant at the confidence level of 99% between *T. aphylla* and *E. camadulensis*, 18 months after the plantation. In addition, the average collar diameter of *T. aphylla* was bigger than that of *E. camadulensis* (35.7 mm versus 25.7 mm).

The smallest canopy diameter, 18 months the plantation, belonged to *T. aphylla* (43 cm), under 75% water depletion scenario and free of superabsorbent. In addition, under 75% water depletion scenario and the application of 100 grams of superabsorbent, canopy diameter of 50 cm was registered for *T. aphylla*. The biggest collar diameter of the seedlings belonged to *E. camadulensis*, under 25% water depletion scenario and the application of 100 and 200 grams of superabsorbent (99 and 97.1 mm, respectively).

Statistical analysis also showed a significant difference between different levels of irrigation and superabsorbent with different species at confidence level of 99%. The average canopy, under 25% water depletion scenario was 85 cm. In contrast, it was measured equal to 58.8 cm, under 75% water depletion scenario. In addition, canopy diameter was bigger at greater levels of superabsorbent (Table 2). Canopy diameter was significant at the confidence level of 99% between *T. aphylla* and *E. camadulensis*, 18 months after teh plantation. In addition, the average canopy diameter of *E. camadulensis* was bigger than that of *T. aphylla* (77.6 cm versus 66.3 cm).

Different experiments on the effect of hydrogel on the plants showed its role in increasing stem biomass, collar diameter, and height and number of the leaves. However, how far these polymers affect depends on several factors, including their hybrid and chemical characteristics, soil texture, plant species, and environmental variables. For this, the effect of the application of hydrogel has persuaded several number of studies. They all have sought the same objective, in this or that way (Sarvas, 2003).

Weight of aerial organs and root

In terms of aerial organs, experiments showed that the lowest weight (171 grams) belonged to *T. aphylla*, under 75% water depletion scenario and free of superabsorbent. The maximum weight of the aerial organs (1221 grams) belonged to *E. camadulensis*, under 25% water depletion scenario and the application of 100 grams of superabsorbent. Statistical analysis also showed a significant difference between different levels of irrigation and superabsorbent with different species at confidence level of 99%. The average weight of aerial organs, under water depletion of 25% was 772.7 grams. In contrast, it was measured equal to 516.6 grams under 75% water depletion scenario. In addition, aerial organs were heavier at greater levels of superabsorbent (Table 2). The weight of aerial canopy was significant at the confidence level of 99% between *T. aphylla* and *E. camadulensis*, 18 months after the plantation. In addition, the aerial organs of *E.*

camadulensis were heavier than those of *T. aphylla* (on average, 906.8 grams versus 383.2 grams).

In terms of root weight, experiments showed that the lowest weight (156 grams) belonged to *T. aphylla*, under 75% water depletion scenario and free of super absorbent. The heaviest root (799 grams) belonged to *E. camadulensis*, under 25% water depletion scenario and the application of 100 grams of superabsorbent.

Statistical analysis also showed a significant difference between different levels of irrigation and superabsorbent with different species at confidence level of 99%. The average weight of aerial organs, under 25% water depletion scenario was 542.4 grams. In contrast, it was measured equal to 314.8 grams under water depletion of 75%. In addition, aerial organs were heavier at greater levels of superabsorbent (Table 2). The weight of aerial canopy was significant at the confidence level of 99% between *T. aphylla* and *E. camadulensis*, 18 months after the plantation. In addition, the aerial organs of *E. camadulensis* were heavier than those of *T. aphylla* (on average, 538.6 grams versus 318.5 grams).

The results from studies by Lawrence *et al*. (2009) on 9 seedlings of tree species did not show any significant difference in the dried weight of roots of the seedlings planted in hydrogel containing soil in 8 species compared to control one. Based on these results, the improvement of absorption coefficient and the reduction of water and food wastes, as well as the enhancement of photosynthesis in the plants have been counted as the advantages of hydrogel enriched soil. The hydrogel levels applied to different soil textures have produced different results. For example, in case of sandy soil, not only both levels differed from control treatment, but also they differed from each other, in that the level of 0.4% had superiority. In case of sandy loam soil, increase of hydrogel level from 0.2% to 0.4% did not cause a significant increase in biomass level. In addition, different plant species have shown different reactions.

All of these researchers eventually concluded that even in conditions, where there was adequate water (close to field capacity) in the soil, adding hydrogel to the soil accelerated root growth and aerial organs of the plants.

Pawlowski and Lejcus (2005) investigated the role of water-absorbing polymers along with geocomposite , as soil supporting materials over vegetative layers. The results suggested that the presence of these materials around the root accelerated the plant growth and developed grass root system.

Asadzadeh (2006) investigated the role of superabsorbent hydrogel (Superab A200) in the reduction of drought stress impact on *Olea europea* seedlings. Results showed that the application of superabsorbent had significant effect on the increase of vegetative traits. Moreover, with the application of superabsorbent, drought stress decreased and such traits as stem length, branch number, and leaf number and area developed, compared to control group. Total fresh and dry weights considerably increased, due to the application of superabsorbent hydrogel. The total fresh weight in the treatments of 0.2% and 0.3% increased to 40.58% to control treatment. These numbers were 23.67% and 55.69% with respect to the total dried weight.

Conclusion

The results from experiments on sandy soil suggest that the measured parameters, except collar diameter, were in better conditions in *E. camadulensis* than *T. aphylla*. Collar diameter of *T. aphylla* is bigger, as its seedling has been prepared from the cuttings of this plant. In addition, all of the measured parameters have improved by the application of superabsorbent. The use of superabsorbent decreases irrigation cycle, too. Several researchers and scientists have reached to the same conclusions. In general, based on the obtained results and the studies by other researchers, it can be concluded that the use of superabsorbent has most often been associated with positive effects on the improvement of the evaluated vegetative features. However, in a number of cases, negative or no effect has been reported. Therefore, conducting further investigations into the effect of superabsorbent materials on the desired species is essential in preparing vegetative development plans. Since, the application of these materials allows the establishment of seedlings in arid and semi-arid regions with higher quality and less cost.

Table 2. Anova analysis of the affected of Stockosorb on Characteristics of *T. aphylla* and *E. camadulensis* Seedlings.

S.O.V	Df	Establishment		Seedling height		Weight			
		After 6 month	After 18 month	After 6 month	After 18 month	aerial organs	root	Collar diameter	canopy coverage
R	2	169.3	468.8	35.6	118.6	29.8	271.3	0.58	56.9
Irrigation (I)	1	1575.5 $^{n.s}$	6302.1*	3152.5*	15660**	776688**	621757**	640.2**	82.7**
Error a	2	402.7	208.3	96.6	88.3	69.3	218.3	1.7	30.1
Superabsorbent (S)	3	256.1 $^{n.s}$	625 $^{n.s}$	511.5**	1000.9**	118127**	91405**	55.9 $^{n.s}$	466.1**
S*I	3	221.3 $^{n.s}$	607.6 $^{n.s}$	36.2 $^{n.s}$	82.0	448.9	3416.2*	16.6	190.7*
Error b	12	355.9	199.7	38.1	111.2	723.1	887.7	5.5	33.4
Species (G)	1	1054.7**	1875 $^{n.s}$	123.5 $^{n.s}$	286.2 $^{n.s}$	3299629**	511020**	1191.1**	1541.3**
I*G	1	638.0	1302.1	2.5 $^{n.s}$	776.0*	213733	105750	5.95 $^{n.s}$	616.3
S*G	3	47.7 $^{n.s}$	208.3**	266.4**	83.7 $^{n.s}$	17424**	10533**	43.6*	15.2 $^{n.s}$
S*G*I	3	186.6**	329.9**	31.4 $^{n.s}$	1314.4**	23823**	11447**	217**	28.7 $^{n.s}$
Error c	16	26.0	52.1	45.3	131.3	941.4	597	9.8	36.4
C.V		5.9%	8.9%	7.4%	6%	4.8%	5.7%	10.2%	8.8%

*, **, ns: significant at $p<0.05$ and $p<0.01$ and non-significant, respectively.

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