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Effect of restoration techniques on Haloxylon ammodendron C.A.Mey

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Abstract

Biological rehabilitation is an effective way in preventing desertification process. Saxaul trees have distributed in Central Asia including Iran. It is a psammophyte species, and grows in sandy deserts, on sand dunes. This species is drought resistance, wind, salinity and limited nitrogen. So, it is widely planted to rehabilitate the arid areas in Iran since 1955. Water scarcity is going to be the major global issue. Supplying water in arid climates is the first step in tree planting. Therefore, different irrigation techniques were considered to invent new water supplying methods for Haloxylon. Ammodendron seedlings. The average annual rainfall in the study area (Sejzi Plain) is about 99 mm and annual evaporation is 1675 mm. The wind speed varies from 1 to 16 m/s. The experimental treatments were considered in a completely randomized design with five replications. Suitable water supplying techniques for saxaul sapling in these arid conditions based on the results are; pitcher irrigation, aquasorb usage, surface stone coverage and Plastic isolation of the planting pits, respectively, as compared with the normal planting and watering. The saplings irrigated with the pitcher technique as the most efficient way show 84 % higher length and 88% greater canopy diameter.

Key words
Pitcher irrigation; Water supply; Saxaul; Desertification; Central Iran.

1. Introduction

Increasing desertification, in most parts of the world and also Iran, is a serious problem. 18 millions of Iran's lands are deserts and sandy (Afkhamoshoara, 1995). Utilization of biotechnology is the most fundamental measure to control wind erosion and desertification. The use of vegetation (including trees, shrubs and herbs) can increase the land surface cover (Zhihai Gao, 2010). The genus Haloxylon (Chenopodiaceae) is represented by 10 species in semi-deserts and deserts of Central Asia, Iran, Afghanistan, Northwest China, Kazakhstan, and Mongolia (Baisalova, 2011). It is a psammophyte, and grows in sandy deserts, on sand dunes. This species is tolerance for aridity, wind, salinity and limited nitrogen. The ecological functions of H. ammodendron plantation include decreasing wind speed, intercepting drift sand, reducing air temperature, etc (Jia, 2008). Therefore, various species of Haloxylon (saxaul tree) are widely planted in the reclamation projects in Iran since 1955 (Ekhtesasi, 2003). However, the most of H. ammodendron plantations have recently degraded, because of the continuous decline of ground water and rodent damage. Desert reclamation projects highly depend on the soil and water supply. In these areas, the most important problems are drought and water scarcity. Population growth in recent decades and the increasing human needs have exploited the surface and underground water resources. This problem is exacerbated during drought periods and especially for central Iran, which is on the dry belt (Arabzadeh, 1996). High temperature and soil cracks increase the water scarcity problem in reclamation projects and ask for new solutions. New planting techniques are shown to be useful in such situations. Cao et al. reported the survival and growth of tree species grown with and without the biodegradable plastic lining (Cao et al., 2008). They suggested that the technique is more suitable than the conventional method. KazemiNezhad et al. (2004) suggested earthenware pipes in afforestation projects of arid lands. Akhter et al. (2004) expressed the hydrogel amendments may improve seedling growth and establishment by increasing water retention capacity of soils and regulating the plants available water supplies, particularly under arid environments. Abu-Zreig et al. (2011) expressed that the average soil moisture measured at the treated plots was always higher and increased with stone coverage percentage as compared to control. Gopinath & Veeravalli (2011) stated that the hydraulic property of the pitchers was highly dependent on the amount of moisture in the soil. The rate of water depletion from the pitcher is higher when the soil around the pitcher is dry than when there is the humidity around the pitcher. In this study, the effects of five irrigations and planting treatments for saxaul (Haloxylon ammodendron) planting including: pitcher irrigation, aquasorb usage, surface stone coverage and plastic lining of the planting pits as compared with the normal planting and watering is experimented.

2. MATERIALS & METHODS

2.1. Study area

This study was carried out in Sejzi plain (32°23′50″ to 32°55′16″ N and 51°56′29″ to 52°07′30″ E) with an area of 43,000 hectares, 40 km distance from Isfahan city. It is the main desertification cause of Isfahan province in Iran. Sejzi plain is 1530 m above sea level and it is relatively flat (the slope varies 0-2%). Average annual rainfall of the region is 106 mm and average annual temperature is 15.2°C. The average annual evapotranspiration (Blaney–Criddle method) is 1675 mm. The climate of this region is dry and cold according to Emberger’s Climate classification. The most important threatening factor in this plain is severe winds from West and South west, North West and the contrary. The wind speed in this region varies from 1 to 16 meters per second. Wind erosion begins at the speed of 5 m/s and it happens 470 times in a year, carrying lots of dust over the city. It is the real cause of frequent respiratory diseases (Desertification Combat project in Sejzi plain, 2010), (Figure 1).

2.2. Method

Saxaul seedlings were planted in the field in a completely randomized design (CRD) with five treatments and five replications. Treatments of the study were included the pitcher irrigation, Aquasorb usage, surface stone coverage, plastic isolation and normal planting. All these treatments were under the same environmental conditions. The soil in the planting pits was replaced with a suitable soil in an unvaried way. The seedlings were protected by fencing around all pits due to the severe damage of rodents such as mice and rabbits. The fencing begun from 60 cm below the surface to protect the roots and better stability of the fences. The seedlings were planted in 5 rows 3 meters’ distance from each other. In this study, plant growth indicators were recorded during the growing season for eight months. It means during primary stages of cultivation which is critical for the establishment of the reclamation. These indicators include seedling’s height and crown diameter. The collected data were analysed by IBM SPSS 20 software. Each of the treatments is explained in the following:

2.3. Pitcher irrigation treatment

Underground irrigation is a traditional methods used in cultivation and fruit orchards (Bastani, 1991). It is performed in this study in the form of pitcher irrigation. To arrange this treatment, after digging the pit and placing the fence, the pitcher was located near the root of the saxaul seedling in the pit, so that, the mouthpiece of the pitcher level at the surface of the ground (Figure 2 and 3). Thus, the pitcher will be filled with the water and it gradually will supply the required water of plants by pitchers' membrane outflow. Every pitcher has a 30 cm height, 4 mm thickness and holds 6 litres of water.

2.4. Superabsorbent treatment

Application of water absorbent materials is highly useful in arid land reclamation, where water shortage is anticipated. These materials store water several times more than their own weight (Al-Harbi, 1999). Aquasorb was used as superabsorbent in the present study. It is a water retainer that, when incorporated into a soil - or a substrate - absorbs and retains large quantities of water and nutrients such as potassium (Rughoo and et al., 1697). Aquasorb can absorb water ideally up to 500 times more than its weight. The crystals swell after contacting with water quickly and create the gel which absorbs water and the dissolved nutrients (Silberbush et al., 1693). Eighty gr. of Aquasorb was mixed with water for each seedling and then, swollen hydrogel was added to the soil (Figure 4).

2.5. Stone coverage treatment

Loss of irrigation water by evaporation and transpiration particularly in places like Sejzi plain, with dry and cold dry climate and 1675 mm average annual evapotranspiration is very high. This treatment is designed to evaluate the effect of adding stone to the superficial soil in reducing the evaporation and increasing the available water for newly planted saxaul (Haloxylon) seedlings in comparison to the other treatments and the control (customary planting method). In the current treatment, after digging the planting each pit and placing its fences and seedling, 80% of the pit's surfaces (2260 cm^2) covered with slabs of 3 cm thickness (Figure 5).

2.6. Plastic isolation Treatment

The contraction of clay in the soil may result in some underground cracks as a result of high evaporation in many playas. There are also so many deep cracks in Sejzi plain, which cause irrigation water fritter and put the water out of reach of the plant. This may be one of the reasons of seedling wilting in many reclamation projects. This new planting technique for seedlings was designed to reduce drainage from the planting pit (Cao et al., 2008) and improving drought resistance of saxaul seedlings. In this treatment, after digging pits to prevent water frittering by the cracks, all base of the pits was lining by plastic film. Small holes considered at the bottom of the pits as a necessary drainage to prevent root putrefaction. A 2*2 m plastic was lining at the bottom filled with soil and the rest over the surface at every side after preparing the planting pits (Figure 6). The used plastics in this treatment were clear in colour and 0.0007 mm thickness. The roots of the plant cross the plastic film, when it is well grown.Control treatment In this study, 5 controls were considered. The soil of the controls was replaced as other treatments to be in the same conditions and normally watered as will be discussed later it should have mentioned that fences considered for all the treatments including the controls, otherwise rodents such destroyed the experiment.

2.7. Seedlings irrigation

The seedlings watered by using a tanker every 15 days. Each seedling received 30 litres water. The pitchers filled with water during the irrigation of all the treatments. It should be remark again that the volume of each pitcher was only 6 litres. Irrigation water was supplied by desertification research centre in Sejzi plain.

2.8. Data Analysis

The Height and Crown Diameter growth of Sexual seedling considered as the plant indexes. These parameters registered every other week during 8-month growth seasons. (This study will continue in future years). Crown Diameter considered orbicular. Then, small and large diameter averaged to calculate the mean coverage diameter. The length between the root's collars up to the outermost tip of the seedlings measured as the plant height.

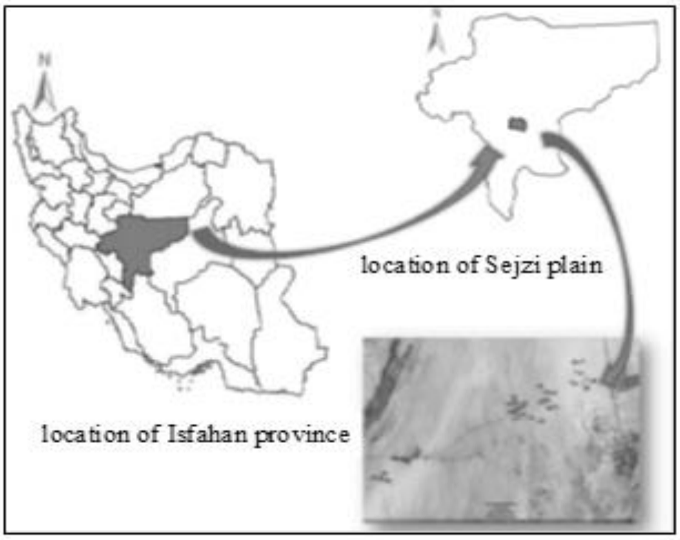

Fig. 1. Study area in Iran

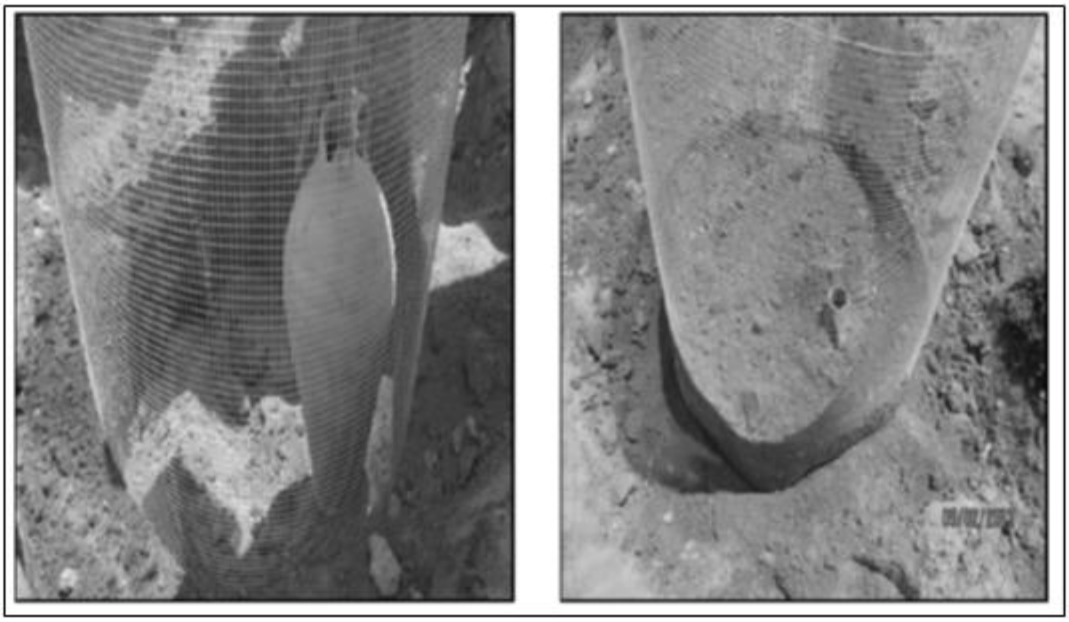

Fig. 2. Preparing pitcher irrigation treatment: Placing the pitcher in the planting pit (left side) and the prepared base (right side)

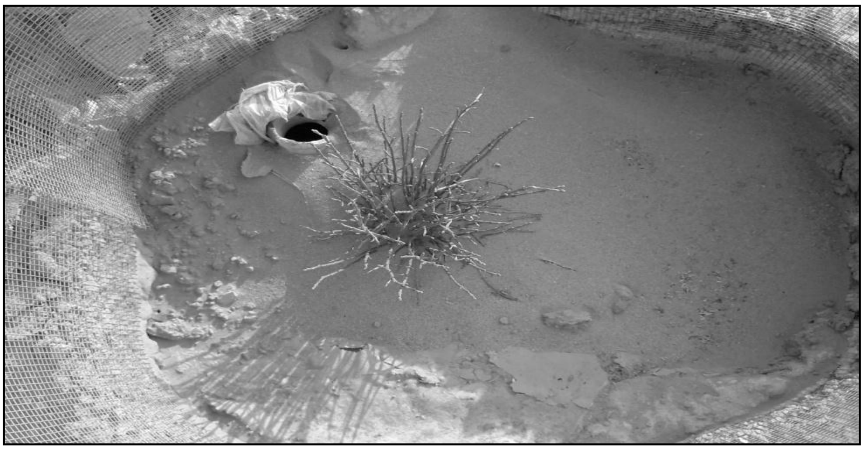

Fig. 3. Established pitcher irrigation treatment

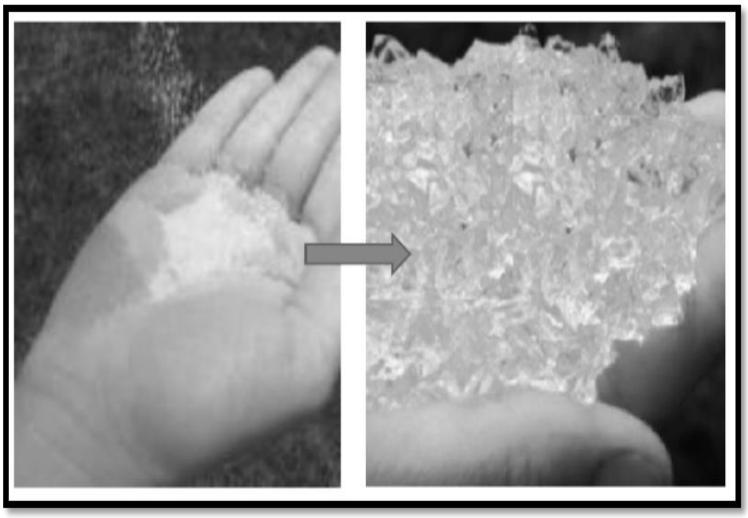

Fig. 4. Superabsorbent (dry and wet)

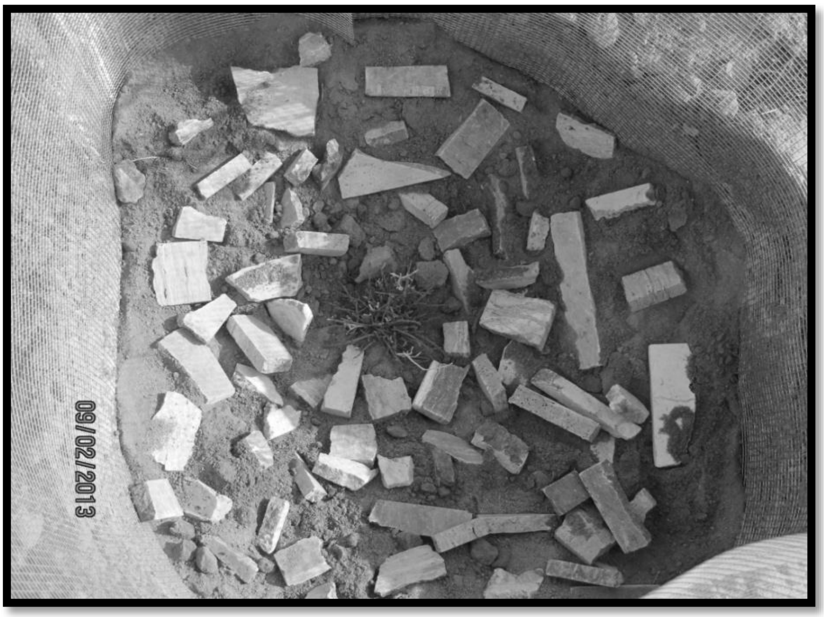

Fig. 5. Stone coverage treatment

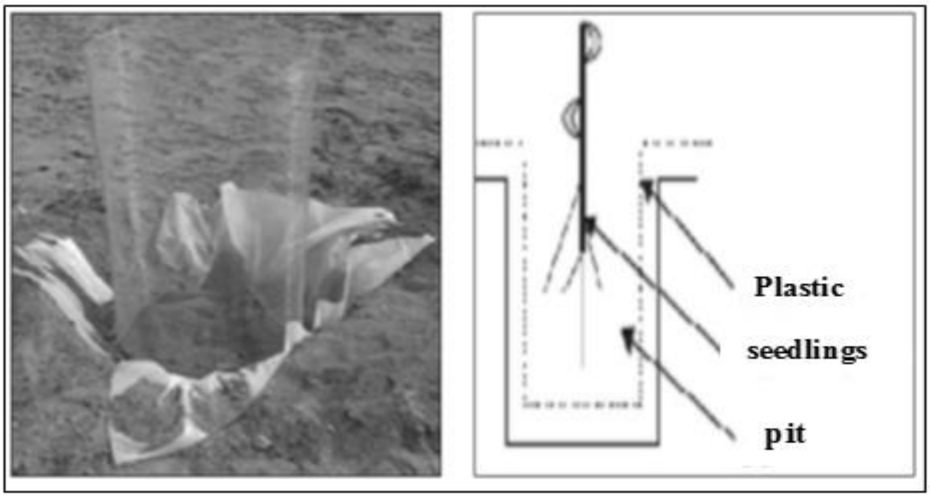

Fig. 6. Plastic isolation treatment

3. RESULTS & DISCUSSION

3.1. Growth parameters

The Height and Crown Diameter growth for every treatment are shown in table 1. Analyses based on completely randomized design (CRD) are also shown in tables 2 and 3. Significant differences (a=0.05) can be seen among the heights and crown diameters of the treatments.

A similarity between Plastic isolation and Stone coverage treatments is determined based on Post-hac analysis, which is shown in charts 1 and 2. Other treatments are separated from each other for the both height and crown diameter factors.

Table1. Height and Canopy Diameter (CD) comparison of Haloxylon ammodendron for each treatment with 5 replications

treatment	pitcher irrigation		Superabsorbent		Stone coverage		Plastic isolation		Control	
replication	Height (cm)	CD (cm)	Height (cm)	CD (cm)	Height (cm)	CD (cm)	Height (cm)	CD (cm)	Height (cm)	CD (cm)
1	78	50	50	41	39	20	33	20	16	10
2	72	52	54	39	41	16	30	20	11	8
3	68	50	49	35	39	29	35	22	13	9
4	80	51	45	30	35	25	25	16	12	9
5	70	55	56	33	30	22	29	16	25	12
sum	368	258	254	178	164	112	152	98	80	48
average	73/6	51/6	50/8	35/6	36/8	22/4	30/4	16/6	16	9/6

Table 2. Variance Analysis of Height of Haloxylon ammodendron

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig
Between Groups	9562.180	4	2390.560	104.391	.000
Within Groups	458.000	20	22.900		
Total	10020.180	18			

Table 3. Variance Analysis of Canopy Diameter (CD) of Haloxylon ammodendron

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig
Between Groups	5291.040	4	1322.760	116.168	.000
Within Groups	222.000	20	11.100		
Total	5513.040	18			

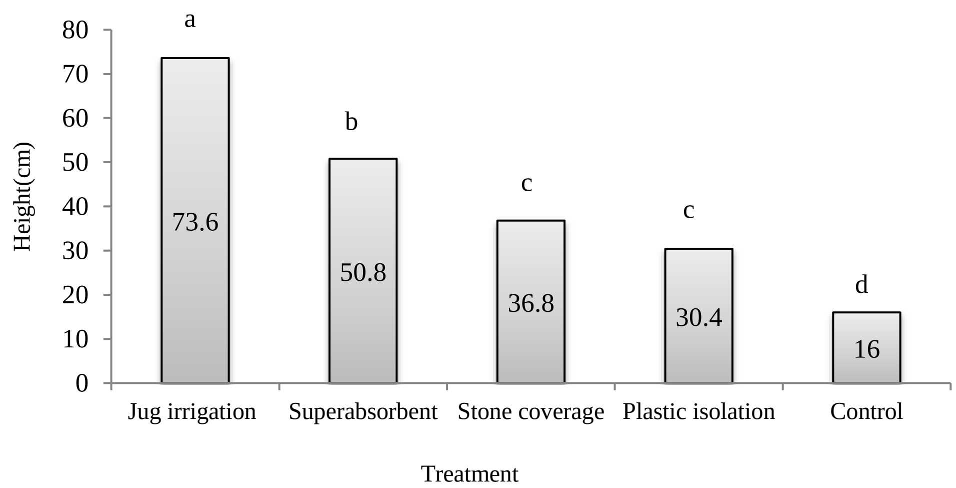

Fig. 7. Comparison of average height of treatments

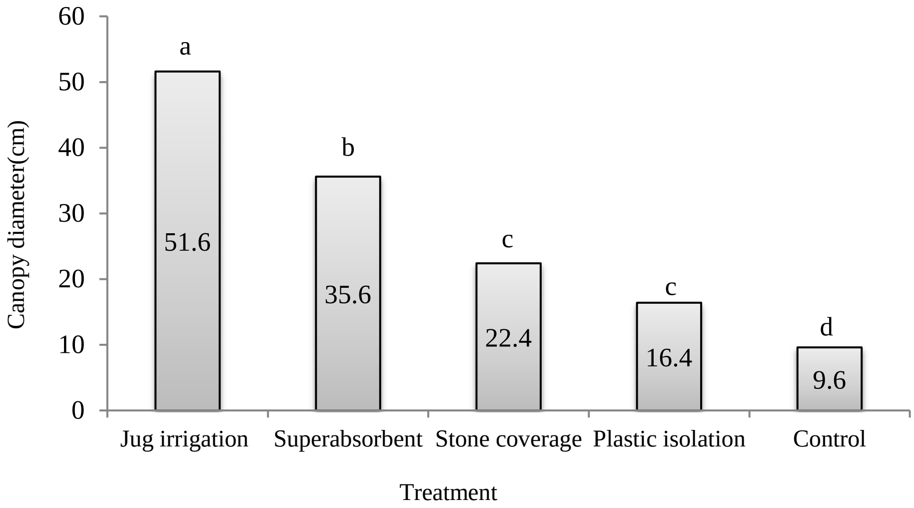

Fig. 8. Comparison of average canopy diameter of treatments

The final findings of this study are the most appropriate irrigating techniques of sexual in Sejzi plan in Iran. However, these findings can be used as guidance in other places with similar environmental condition as it can be seen in similar studies (Cao *et al.*, 2008). Based on the results, suitable water supplying technique for sexual sapling in these arid conditions are; pitcher irrigation, aquasorb usage, surface stone coverage and plastic isolation of the planting pits in comparison to the normal planting and watering, respectively. The saplings irrigated with the pitcher technique as the most efficient way show 84% higher length and 88% greater canopy diameter. Although this study has been done in a single year but water supplying in primary stages of tree planting in arid regions has a crucial importance in survival of newly planted seedlings. The efficiency of underground irrigation especially in the form of pitcher irrigation is more eminent in the regions with high average annual evapotranspiration. Other benefits of it comprise; prevention of severe water drainage by cracks, abundance materials to manufacture of the pitchers, simple manufacturing technology and gradual leakage of water for the use of plant. So this method is considered to be perfectly suitable with the characters of the study area in Sejzi plain. Earthenware pitchers' membrane is well adjusted with soil. So that hydraulic conductivity doesn't cut off between pitchers' membrane and the soil. There is a kind of reciprocation between them, which may be termed "auto regulation properties". Automatic water leaking control is possible only through advanced and expensive cybernetic irrigation systems, while pitchers also manage this job; after implanting pitchers in the soil, its earthenware membrane gives more water to the soil as a result arid soil suction. But, the pitchers leaking reduce when the soil around it becomes wet. It makes the water available to the plants whenever it is necessary and prevents its useless drainage to the depth of the soil (Bastani, 1991). It worth mentioning the growth of seedling in pitcher irrigation treatment with respect to the height and crown diameter during the first months is almost the same with 2 years old seedling planted in the area in the same condition as the control treatments. As it is described in the method, each pitcher received only 6 litters of water while other treatments received 5 times more water. Success in superabsorbent treatment is related to scattered rainfall in region which happens sometimes in the study area and also works well with artificial irrigation, so that types of polymers absorb the water which is more than use and make it available to the roots whenever it is needed. Application of superabsorbent hydrogel also is a recent irrigation technique in the arid regions which can be a solution in reclamations to the condition of well implementation (Yajuan et al., 2011). Plastic isolation treatment and Stone coverage treatment almost act the same with moderate function. The controls showed the least efficiency for retaining water and the planted saxaul in this way remained very small. It should be noted the cost of irrigation with pitcher is more than all the other treatments, but its functionality and efficiency to retain water make it worthful.

4. CONCLUSION

In this study, the effects of five irrigations and planting treatments for saxaul (Haloxylon ammodendron) planting including: pitcher irrigation, aquasorb usage, surface stone coverage and plastic lining of the planting pits in comparison to the normal planting and watering is experimented. Cultivated seedlings in pitcher irrigation are almost equal to 2-year-old seedlings in the region in terms of height and canopy in early stages of growth, while the amount of water required for irrigation in any 25-day period in the pitcher method is one-fifth of other methods. The reason for its success is the self-regulating property in the wall of the pitcher, which causes the water gradually become available to the plant.

References

- Abu-Zreig, M. Tamimi, A. and Alazba, A. (2011). Soil Erosion Control and moisture Conservation of Arid Lands with Stone Cover, Arid Land Research and Management, 25(3), 294–307.
- Afkhamoshoara, M. (1995). Effect of saxaul on situation changes understory species in the south of Khorasan, Animal Science, 29: 31-33.
- Akhter, J. Mahmood, K. Malik, KA. Mardan, A. Ahmad, M. and Iqbal, MM. (2004). Effects of hydrogel amendment on water storage of sandy loam and loam soils and seedling growth of barley, wheat and chickpea. Plant, Soil Environment, 50(10), 463–469.
- Al-Harbi, AR. Al-Omran, AM. Shalaby, AA. Nd. And Choudhary, MI. (1999). Efficacy of a Hydrophilic Polymer Declines with Time in Greenhouse Experiments. HortScience, 34(2), 223–224.
- Arabzadeh, N. (1996). Effect of different methods of pruning plated forests of on Haloxylon. Proceedings of the second national conference on desertification and different methods to desertification Combat, 17-19 March 1996. Iran, Kerman, 24-31.
- Baisalova, G. and Erkasov, R. (2011). Amino-and fatty-acid composition of Kazakhstan Haloxylon species. Chemistry of Natural Compounds, 47(1), 159-160.
- Bastani, SH. (1991). Underground irrigation by earthenware pipes. Proceedings of Seventh Conference National Committee on Irrigation and Drainage of Iranian, 6-8 November 1991: 1-22.
- Cao, S. Chen, L. Liu, Z. and Wang, J. (2008). A new tree-planting technique to improve tree survival and growth on steep and arid land in the Loess Plateau of China. Journal of Arid Environment, 72(7). 1374–1382.Ekhtesasi, M. (2003). Determine the minimum density of Haloxylon seedlings for design windbreaks tree and control wind erosion in central Iran. Proceedings of the first national conference on saxaul (Haloxylon sp.) and saxaul; plantation, 10-12 October 2003. Iran, Kerman: 12-20.
- Gopinath, K. and Veeravalli, S. (2011). Auto-regulative capability of pot/pitcher irrigation, Journal of Science & Industrial 70: 656-663.
- Jia, ZQ. Ji, XM. Ning, HS. And Liang, YQ. (2005). Ecological function assessment of artificial Haloxylon ammodendron forest, Journal of Soil Water Conservation, 28(4), 66–69.
- KazemiNezhad, A. Baghestani. N. and Karimi, A. (2004). An investigation of affection of disparate irrigation methods on establishment of fruitful and unfruitful sprees of tree in desert areas, Animal Science, 71, 89-94.
- Report of Natural Resources services in Isfahan province. (2010). Desertification Combat project in Sejzi plain.
- Rughoo, M. Govinden, N. and Gowrea, B. (1697). Yield and characteristics of cooking tomato var. Sirius. Revue Agricole et Sucriere de Iile Maurice, 76(2), 38-43.
- Silberbush, M. Adar, E. and Malach, Y. (1693). Use of a hydrophilic polymer to improve water storage and availability to crops grown in sand dunes, Agricultural water Management, 23, 303-313.
- Zhu, Y. and Jia, Z. (2011). Soil water utilization characteristics of Haloxylon ammodendron plantation with different age during summer. Journal od Arid Environment, 31(6), 341-346.
- Gao, Z. Li, C. Yang, X. and Ci, L. (2010). Engineering and Technological Measures for Combating Desertification, Desertification and Its Control in China: 427-463.