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Using different irrigation techniques in desert restoration with *Haloxylon ammodendron*

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Abstract:
Sejzi Plain, a deserts in central Iran, is located in east of Isfahan Province and it is the main desertification pole in Province. This area suffers increasing desertification due to harsh climatic conditions and man-made factors. Biological rehabilitation is an effective way in preventing desertification process. This implementation not only limitate the aforementioned problems by biomass and forage production but also has many side benefits. Saxaul tree is distributed in Central Asia including Iran, West-Afghanistan, Turcomania, Gobi Desert and china. It is a psammophyte, and grows in sandy deserts, on sand dunes. This species is tolerance for aridity, wind, salinity and limited nitrogen. So it is widely planted in the reclamation of arid areas in Iran since 1955. Water scarcity is going to be the major global issue and particularly water supplying in arid climates is the first step in tree planting. Therefore, in order to invent new water supplying methods, different irrigation tequniues were considered 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 speeds differ from 1 to 16 m/s. To achieve the goal 5 irrigation treatments with 5 replications in a completely randomized design were used. Based on the results, suitable water supplying technique for saxaul sapling in these arid conditions are respectively; jug irrigation, aquasorb usage, surface stone coverage and Plastic isolation of the planting pits in comparison to the normal planting and watering. The saplings irrigated with the jug technique as the most efficient way show 84% higher length and 88% greater canopy diameter.

Key words: water supply, saxaul, desert combat, Central Iran

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, because of the continuous decline of ground water and rodent damage most of *H. ammodendron* plantations have degraded recently. Desert reclamation projects highly depend on the soil and water supply. In these areas, drought and water scarcity are the most important problems. Population growth in recent decades and the increasing human needs has 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 and et al. reported the survival and growth of tree species grown with and without the biodegradable plastic lining [Cao

and et al. 2008]. They suggested that the technique is more suitable than the conventional method. KazemiNezhad et al. [2004] suggested earthenware pipes in arid land afforestation projects. 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 compared to control. In this study the effects of five irrigation and planting treatments for saxaul (*Haloxylon ammodendron*) planting including: jug irrigation, aquasorb usage, surface stone coverage and plastic lining of the planting pits in comparison to the normal planting and watering is experimented.

Study area:

This study is performed 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 hectare, 40 km distance from Isfahan city center. 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 rain of the region is 106 mm and average annual temperature is 15.2°C. And average annual evapotranspiration (Blaney–Criddle method) is 1675 mm. The climate of this region according to Emberger's Climate classification is dry and cold. 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 happen 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).

Method:

Saxaul seedlings were planted in the field, using a completely randomized design (CRD) with five treatments and five replications. Treatments of the study include: jug 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. Respect to the severe damage of rodents such as mice and rabbits, physical protection by fencing around all pits were considered to protect the seedling. The fencing begins from 60 cm below the surface to protect the roots and better stability of the fences. The seedlings 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 analysed by IBM SPSS 20 software. Each of the treatments is explained in the following:

Jug irrigation treatment: Underground irrigation is a traditional methods used in cultivations and fruit orchards [Bastani, 1991]. It is performed in this study in the form of jug irrigation. To arrange this treatment, after digging the plant pit and placing the fence, then the jug is locating near the roots of the saxaul seedling in the pit, so that the mouthpiece of the jug level at the surface of the ground (Figure 2 & 3). Thus the jug will be filled with the water and it will gradually supply the required water of plants by jugs' membrane outflow. Every jug has a 30 cm height, 4mm thickness and holds 6 litres of water.

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 is 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 contact with water quickly and create the gel which absorbs water and the dissolved nutrients [Silberbush and et al., 1693]. For each seedling 80 gr. Aquasorb mixed up with water and then swollen hydrogel added to the soil which of the planting pit (Figure 4).

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 evaporation reduction and increasing the available water for newly planted saxaul (*Haloxylon*) seedlings in comparison to the other treatments and in comparison to 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).

Plastic isolation Treatment: In many playas as a result of high evaporation the contraction of clay in the soil may result in some underground cracks. In Sejzi plain, there are also so many deep cracks which cause irrigation water fritter and put the water out of plants reach. 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 and 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. After preparing the planting pits a 2*2 m plastic was lining at the bottom filled with soil and the rest over the surface at every side (Figure 6). The used plastics in this treatment were clear in color 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 considered. The soil of the controls were replaced as other treatments to be in the same condition and watered normally as will be discussed later it should mentioned that fences considered for all the treatments including the controls otherwise rodents such destroyed the experiment.

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

Data Analysis: The Height and Crown Diameter growth of Saxaul 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 in order to calculate the mean coverage diameter small and large diameter averaged. The length between the root's collars up to the outermost tip of the seedlings measured as the plant Height.

Results:

Growth indicators: The resulted 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. Based on post-hac analysis a similarity between Plastic isolation and Stone coverage treatments is determined which is shown in charts 1 and 2. Other treatments are separated from each other for the both height and crown diameter factors.

Discussion and conclusion:

The final findings of this study are the most appropriate irrigating techniques of saxaul 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 saxaul sapling in these arid conditions are respectively; jug irrigation, aquasorb usage, surface stone coverage and Plastic isolation of the planting pits in comparison to the normal planting and watering. The saplings irrigated with the jug 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 jug 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 jugs, 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 jugs' membrane is well adjusted with soil. So that hydraulic conductivity doesn't cut off between jugs' 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 jugs also manage this job; after implantation jugs in the soil, its earthenware membrane gives more water to the soil as a result arid soil suction. But when the soil around it becomes wet the jugs leaking reduce. This 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 jug 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 jug received only 6 liters 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 these types of polymers absorbs the water which is more than use and make it available to the roots whenever it is needed. Application of superabsorbent hydrogel is also 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 acts almost similar and their function moderate. 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 jug is more than all the other treatments but its functionality and efficiency to retain water make it worthful.

References:

1-Afkhamoshoara, M. Effect of saxaul on situation changes understory species in the south of Khorasan. *Pajouhesh & Sazandegi*. 1995, 29, 31-33.

1. Zhihai, Gao.; Chaosheng, Li.; Xiaohui, Yang.; Longjun, Ci. Engineering and Technological Measures for Combating Desertification. *Desertification and Its Control in China*. 2010, 427-463.

2. Baisalova, G. Zh.; Erkasov, R. Sh. Amino-and fatty-acid composition of Kazakhstan Haloxylon species. *Chemistry of Natural Compounds*. 2011.

3. Jia, Z.Q.; Ji, X.M.; Ning, H.S.; Liang ,Y.Q. Ecological function assessment of artificial *Haloxylon ammodendron* forest, *Bulletin of Soil and Water Conservation*. 2008, 28 (4), 66–69.

4. Ekhtesasi, M. 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 in I.R. Iran*, Kerman. 2003, 12-20.

5. Arabzadeh, N. 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*, Kerman. 1996, 24-31.

6. Cao, S.; Chen, L.; Liu, Z.; Wang, J. 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 Environments*. 2008, 72, 1374–1382.

7. KazemiNezhad, A.; Baghestani, N.; Karimi, A. An investigation of affection of disparate irrigation methods on establishment of fruitful and unfruitful splees of tree in desert areas. *Pajouhesh & Sazandegi*. 2004, 71, 89-94.

8. Akhter, J.; Mahmood, K.; Malik, K.A.; Mardan, A.; Ahmad, M.; Iqbal, M.M. Effects of hydrogel amendment on water storage of sandy loam and loam soils and seedling growth of barley, wheat and chickpea. *Plant Soil Environ*. 2004, *50*, 463–469.

9. Abu-Zreig, M.; Tamimi, A.; Alazba, A. Soil Erosion Control and moisture Conservation of Arid Lands with Stone Cover. *Arid Land Research and Management*. 2011, 25, 294–307.

10. Desertification Combat project in sejzi plain. Report of Natural Resources services in Isfahan province. 2010.

11. . Bastani, Sh. Underground irrigation by earthenware pipes. *Proceedings of Seventh Conference National Committee on Irrigation and Drainage of Iranian*. 1991, 26, 1-22.

12. . Al-Harbi, A.R.; Al-Omran, A.M.; Shalaby, A.A.; Choudhary, M.I. Efficacy of a Hydrophilic Polymer Declines with Time in Greenhouse Experiments. *HORTSCIENCE*. 1999, 34(2), 223–224.

13. **Rughoo, M.; Govinden, N.; Gowrea, B. Yield and characteristics of cooking tomato var. Sirius. Revue Agric. *Sucr. Ile Maurice*. 1697, 76(2), 38-43.**

14. **Silberbush, M.; Adar, E.; Malach, Y. Use of a hydrophilic polymer to improve water storage and availability to crops grown in sand dunes. *Agricultural water Management*. 1693, 23, 303-313**.

15. Yajuan, Zh., Zhiqing. J., 2011. Soil water utilization characteristics of Haloxylon ammodendron plantation with different age during summer. Journal of Arid Environments 72, 341-346.

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

treatment	Jug 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

Table2. Anova table for 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			

Table3. Anova table for 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			

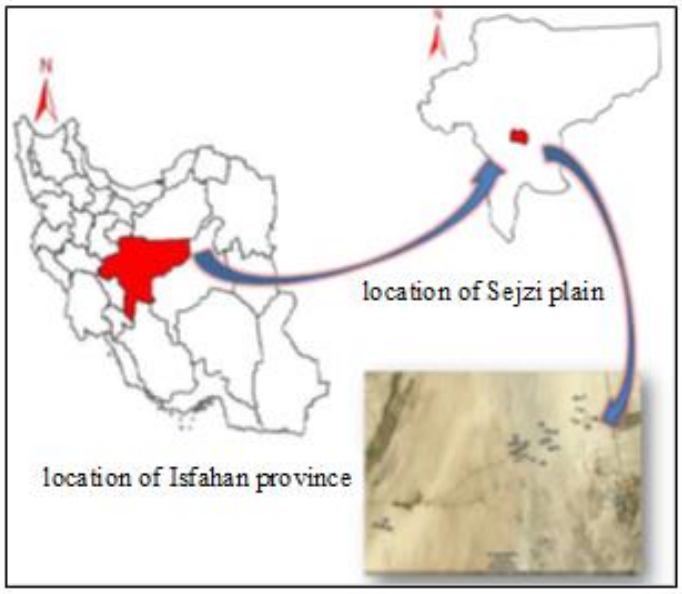


Figure1. Study area in Iran

Figure2. Preparing jug irrigation treatment: Placing the jug in the planting pit (left side) and the prepared base (right side).

Figure3. Established jug irrigation treatment

Figure4. Superabsorbent (dry and wet)

Figure5. Stone coverage treatment

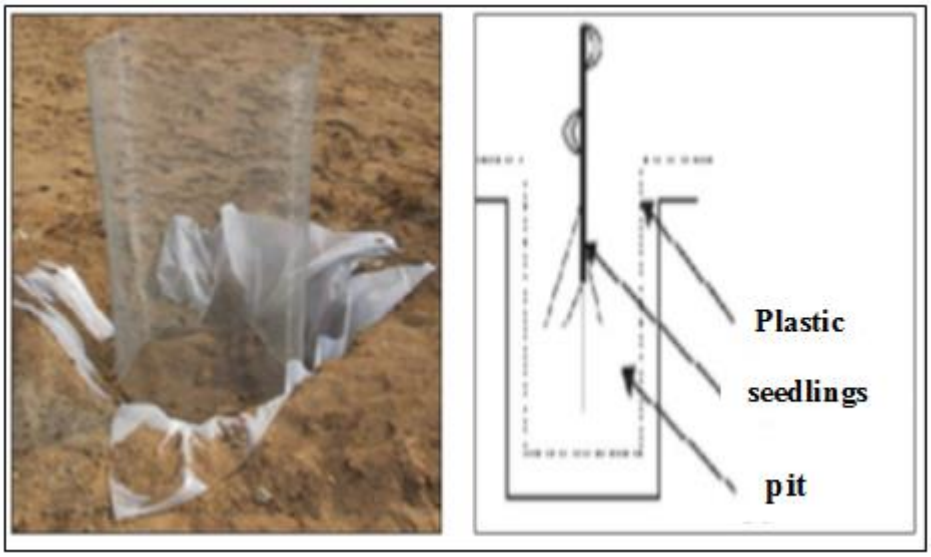
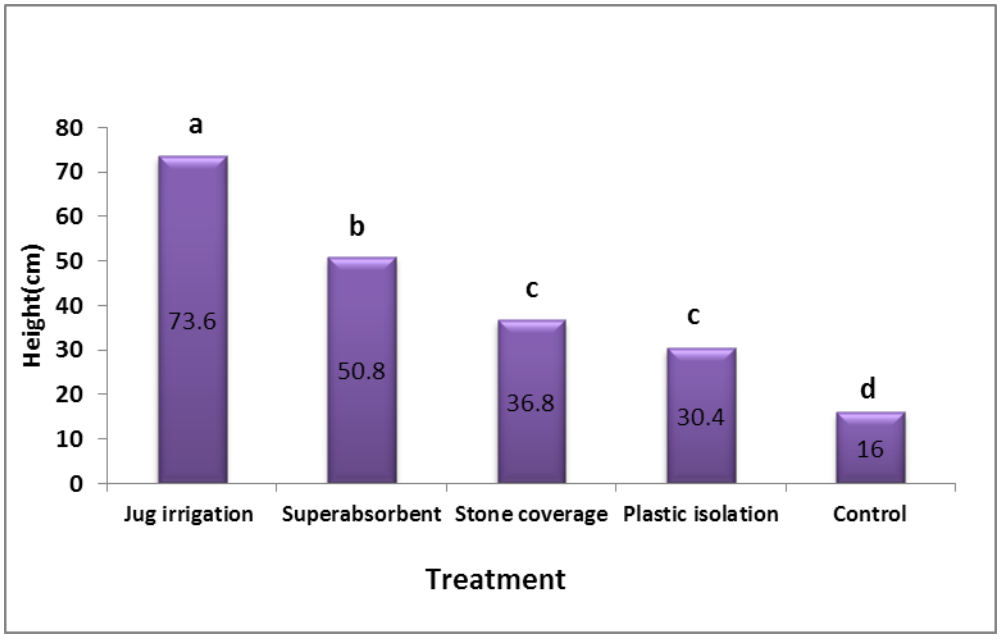
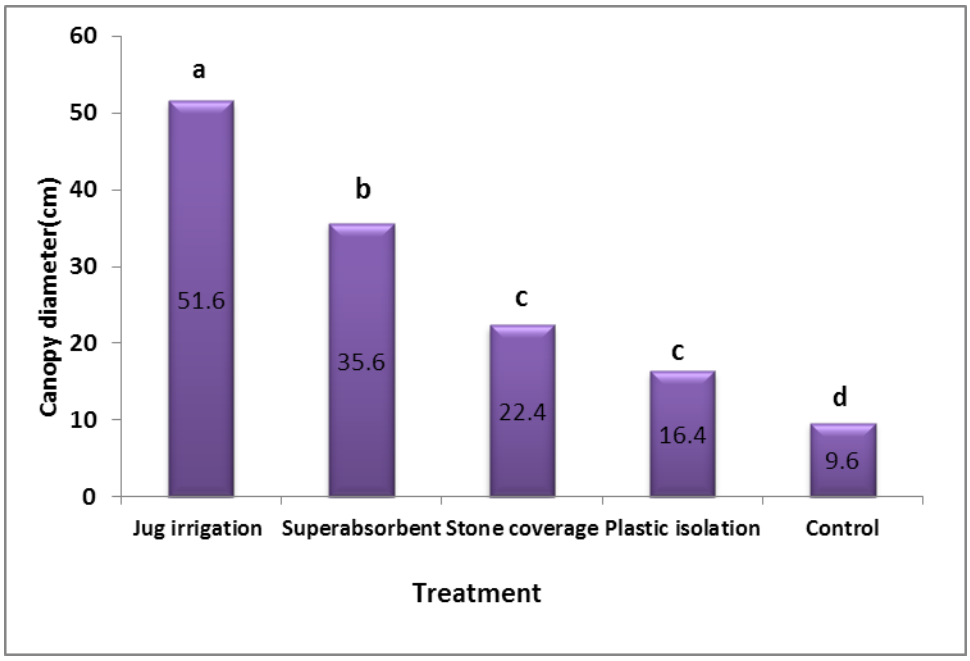


Figure6. Plastic isolation tretment



Graph1. Comparison average height of treatments



Graph2. Comparison average canopy diameter of treatments