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Studying the Impact of Mulch Materials on the Physio-Morphological Characteristics of *Nitraria schoberi* L.

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Abstract:

Iran has lots of arid areas which the annual precipitation is low. Therefore, establishment of plants is hard. Therefore, at present study, the effectiveness of biological hydrogel (biological mulch or b), PLANTBAC vegetation layer (Pb), sand (sa), and barley straw (st) with rain harvesting techniques in micro-catchment scale (inter-row system) on plant characteristics of *Nitrariaschoberi* including establishment rate, fresh and dry biomass, etc. was tested. According to the results, plant height was significantly higher in the sand treatment than in other treatments. The dry yield of aerial parts indicated that all treatments showed a significant difference from the control. Leaf dry and fresh weight showed that both PLANTBAC treatment and sand were significantly more than the control. Root fresh and dry weight was significantly higher than the control on all four mulch treatments. According to the results, there is no significant difference between the environment (non-micro-catchment and micro-catchment) and the different treatments, so, we can propose each treatment by considering its price for the region. it can be concluded that some treatments had more effect on plant traits than the others, because of better absorbing adequate moisture and preparing nutrients for plants. Hence, they can be proposed for the region. Thus, concerning the effectiveness of present mulches on a variety of plant properties, the price of each, availability, and condition of the area, they can be used to establish plants in desert areas and restore these areas by controlling dust and dunes movement, soil erosion, etc.

Keywords:

Nitrariaschoberi, amendments, physio-morphologic characteristics, deserts, Semnan.

Introduction

Iran has a hot and dry climate and the annual precipitation is low. In addition to the lack of rainfall, temporal and spatial distribution is also very poor(Kianian, 2022, 2019; GanjiKhorramdel, 2018; Yang et al., 2018). Soils in these areas have not been developed and have low organic matter and in most casesare alkaline. The plantsof these areas are resistant to drought and salinity and their growth form is mostly as shrub and bush (Luo et al., 2022; Ahmadi, 2019; Shilev, 2020; Ahmadi and Saeidi, 2018; Azimi et al., 2018). Reducing desertification and rehabilitation of degraded areas is needed to reclaim and maintain the vegetation in these areas. In addition,the vegetation increases productivity and stability against the risk of erosion and reducessalinity (El-Sheikh *et al.*, 2010). Also, the plantshave an industrial value, forage, conservation (soil and reduce erosion), scenic beauty, etc. (Javaid et al., 2022; Ashraf *et al.*, 2018; Hasanpori*et al.*, 2020; Wang, 2009, Wang, 2011 andKabiri, 2015; Benabderrahim et al., 2018). One of the most important and most usable development and regeneration methods of vegetation is planted. But the lack of precipitation, high evapotranspiration, and inappropriate rainy season leads to destroying seedlings, especially in the critical period of establishment and projects failureof planting in arid areas (Kianian, 2022). Also, high implementation costs and provide the water needed for irrigation at the beginning of the planting periodis a very serious obstacle to the development of the cultivated area.It has been reported thathydrogel networks improve aeration and drainage (Bearce, McCollum, 1977), reduce plant water stress (Teame*et al.*, 2017; Li*et al.*, 2018; AbediKuhpai, and Sohrab, 2004; Gehring, Lewis, 1980; Li et al., 2017), and improve seed coating (Pamuk, 2004). Wallace and Wallace (1986) stated that the most favorable results for the emergence of the seed and water penetration are obtained of an anionic polymer and cationic polymer was less effective. In addition, appropriate amendments affect the antioxidant defense mechanisms (El–Metwally et al., 2021; Benabderrahim *et al.*, 2018; Cordeiro*et al.*, 2011; Song et al., 2019). Hydrogelshave been used for the establishment of seedlings and transplanted trees in arid areas of Africa and Australia to increase plant survival (Alharb, 2015; Specht, Harvey-Jones 2000; Save 1995; Callaghan *et al.* 1988, 1989). Specht, Harvey-Jones (2000) found that less tolerant tree species to drought reacted more favorably to the use of hydrogels. when the hydrogels in the bed of growth were placed total dry weight *brayleana Flindersia* (maple Queensland) and *muelleriDysoxylum* (red beans) increased, while species resistant to drought *Flindersiaaustralis* (teak Australia) and Grevillea robusta (oak silk) did not show a significant increase in total dry weight. In an experiment, irrigation was stopped six days, so all the control seedlings were destroyed, but the survival rate of modified soils with hydrogel was 57% and 71% (Iqbal et al., 2022; Charles *et al.*, 2017; Callaghan *et al.*, 1989; AbediKuhpai, and Sohrab, 2004). Drought-sensitive plants such as *Petunia parviflora* (Atlas), reacted well to the hydrogel in arid conditions, and the dry weight and flowers number increased (Shilev, 2020; Boartright*et al.*, 1997).

Arikiriza*et al.*, (2009), seedlings of 9 species of *Eucalyptus grandis*, *Eucalyptus citriodora, Pinuscaribaea*, *Araucaria cunninghamii*, *Meliavolkensii*, *Grevillea robusta*, *Azadirachtaindica, Maesopsiseminii* and *Terminalia superba* planted into the pots filled with five types of soil sandy, sandy loam, loam, silt loam and clay with two levels of 2.0 and 4.0 w% enriched hydrogels. Pots kept in the greenhouse and under non-stress conditions and the amount of biomass based on dry weight and according to root, stem, leaf, and twig were measured. After eight weeks the plants were harvested and measured. The results showed a significant difference in root dry weight of the seedlings planted in soil containing hydrogel at 8 species of plants compared to control, and the dry weight of stem, leaf, and twig all of the species have given a significant increase compared with the controlHydrogel used in different textures of the soil in this study had different results.For example, both levels in sandy soil in addition to having difference with the control, showeda difference together and 4.0% was better, but there was no significant increase in biomass in sandy loam soil with an increase of hydrogel from 2.0 to 4.0 percent. The plant species also have different reactions. *Eucalyptus citriodora* unlike other species in both the hydrogel had similar production in the loamy soil and the *Meliavolkensii* with increasing hydrogel reacted to a reduction in root dry weight. Reduction in root dry weight by increasing the amount of hydrogel in the heavier soils is repeated in several other plant species, which may be due to the ease of access to water and no need for further development of the plant root system (Silva et al., 2020). Final increase of production 9 species with the use of hydrogel from 150 to 220 percent compared to the control was assessed.To reveal the relationship between the increase in available water and plant growth, the increase in available water of the two types of sandy loam and sandy clay soils was measured 3.2 and 1.8 times, respectively, compared to the control, but despite this very significant difference, the difference in crop production in these two types of soil was only 16% (Verma et al., 2018; Kader et al., 2017; Sharma and Bhardwaj, 2017; Rashid et al., 2019).

Materials and methods

Study Area

The study was carried out by planting seedlings for 2 years in the Natural Resources Research Station of Semnan (the station is part of the typical desert area of Semnan and has a large extent (Figure 1). The average rainfall is 109.3mm, the evaporation rate, 2582.3 mm, the number of sunshine hours, 3134.5 hours, the average annual temperature, 18°C, the minimum moisture content, 23%, and the number of frost days is 19 days. Maximum rainfall occurs in winter in this region. The city is classified in an arid and cold climate based on the Domarten method.

The plant and its properties

-Nitrariaschoberi

Nitrariaschoberi is theplant that treatments are tested on. Therefore, to introduce *Nitrariaschoberi,* some properties of this plant is given below. *Nitrariaschoberi* is of Nitraria gender and Zygohpylaceae family with five species as schoberi, reyusa, sibirica, sphuerocarpa and komaroui (Kianian, 2022; Mojiri, 2011). Only, *Nitrariaschoberi* species is native to Iran. This plant is woody and highly branched and has rough and thorny branches (Figure 2). Its inflorescence is as tail-scorpion pistil with white color and usually will appear in late April.

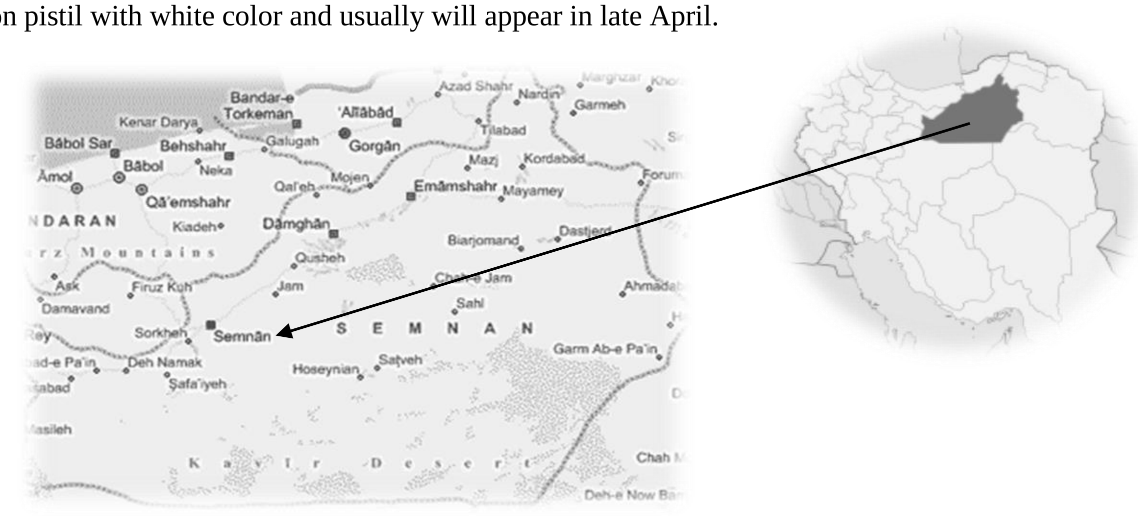

Figure 1. Map of the study area.

Its fruit is a drupe colored brown to black, containing a seed that is visible in late June. Leaves are fleshy and stems are sharp and woody at the end. The most important values of *Nitrariaschoberi* includes the role of conservation (dunes stabilization and prevention of soil erosion), use the fruits in the biological synthesis of gold and silver nanoparticles, forage production value, industrial value, especially in the dyeing, softening the air, refuge, wildlife, landscape beauty, and medicinal value. medicinal value includes 18 alkaloids, flavonoids, and phenolic compounds and 2 pseudo-serotonins, organic acids, antioxidants, etc. (Sharifi-Rad*et al.*, 2016, 2015, 2.14) In the case of reproducing it must be said that, so far, have experienced several methods, including direct sowing (seeding and hill drop planting), cuttings and seedling production in plastic pots, which the best method is to produce pot seedlings.

Figure 2. *Nitrariaschoberi* plant in the site

-Amendments materials and mechanisms of their action

One of the best and newest methods in further savings in water consumption is to use of PLANTBAC panel and biological hydrogels. The following explanations are given about them.

-PLANTBAC

Components forming the product contain albumin biopolymers, water, minerals, and recyclable herbal elements. Its life is 5 to 8 years. By adding natural nutrients, restores the soil and prohibits soil erosion by water and wind. Release and absorption of essential nutrients are the direct effects of this layer. In desert combating, the spread of vegetation could be done quickly due to keeping the soil moisture.

-Biological hydrogel

Biological absorbent moisture materials used in the study are a mixture of microbial and plant polymers, which about 40% by weight have water-absorbing properties and, unlike super-absorbents prevents salt accumulation in the root zone due to less water absorption. Its pH is 0.5 ± 7 and has no salt. 90% germination index tests showno hydrogel phytotoxic effects on plants. This as a carrier of used microorganisms in the soil (fertilizer or biological poison) leads to increase soil biological activity. Dry areas make some Mucilage properties around the roots that prevent stress to the plant.

-Research Methodology

In the method, the seeds are planted in plastic pots in the nursery of Hasanabd station, Damghan, and then the seedlings are transferred to Semnan research station. Then,the seedlings were planted in the form of a split-plot design with a randomized complete block base with 3 replications and 10 observations in the first week of December 2021. The first irrigation was performed simultaneously with planting seedlings. The treatments are as follows:

- Rainwater harvesting technique at two levels (technique application, non-technique application).

- Mulch and moisture-absorbent materials in five levels (biological hydrogel or biological mulch), PLANTBAC, sand, straw, and control treatment)

In the location of the project, in the Natural Resources Research Station of Semnan´ Agriculture and Natural Resources Research Center, it was drilled 150 holes to the diameter and depth of 50 cm and the treatments were placed in each repetition. The pits' distance from each side was 3 m. In the sand treatment, sand (diameter 2 to 5 mm) with a thickness of 5 cm was placed in the canopy of the plant. For barley straw treatment was acted the same and some straw to a thickness of 5 cm was placed in the canopy of the plant. For biological hydrogel, at first 140 liters of water in a barrel of 220L was heated until 80°C and 40 ml of concentrated hydrogel was shed into it to be thinner. Then, 2 Liter is shed in the soil under the plant and 1 Liter in the soil next to the seedling. For treatment of PLANTBAC, at first, one number was halved and two halves were placed to a short distance from each other at the hole (one half in the bottom and then another above it). Finally, the seedlings were planted. For applying the technique of rainwater harvesting according to the area condition (slope, climatic factors, soil depth, etc.) was used inter-row systems were treated for all repetitions until its effect on plant growth be determined. The irrigation time of the seedlings was in summer during 4 irrigations (15 June, 15 July, 15 August, and 15 September) in the first year.

The volume of water for irrigation in all treatments was based on reaching humidity to the control plant wilting point and the amount of water needed to reach to field capacity level in the control plant. Finally, due to the volume of water consumption (constant against control) for treatments and the resulting biomass in each treatment, water use efficiency (WUE) and the efficiency of the technique were determined. In the end, sampling of soil factors was conducted according to the relevant instructions. Then, the samples were transferred to laboratories and they were prepared, and then each one was measured according to the relevant guidelines by using devices or methods.
In the third year, characteristics of survival percentage (establishment), biomass rate, growth rate (leaf area and height), as well as fresh and dry weight of roots and shoots and dry shoot yield according to relevant methods (meter, balance, etc.) were measured in the field and laboratory.
To analyze the data, first, the normality of experimental errors was performed by Shapirovilk, Kolmogorov-Smirnov, Kramer van Misses, and Anderson Darling tests for each trait (Table 1). The results showed that the experimental errors were normal. The experiment was performed as a split-plot design in a randomized complete block design with three replications. In this way, the environmental factor at two levels (non-micro-catchment and micro-catchment) and the mulching factor at five levels (control, PLANTBAC vegetation layer, biological hydrogel, straw, and sand) are considered as independent variables and traits as dependent variables in the experiment. Then, analysis was performed using SAS software version 9.1.3. Mean comparisons were performed using LSD test if. Pearson correlation was also performed for correlation between different traits. The results for each trait are given below.

Results and discussion
Analysis of characteristics of the plant such as survival (establishment), biomass, growth rate, and aerial dry yield are provided in table 1. Given that the treatmentsPLANTBAC and bio- hydrogel were done for the first time in Iran and the world, thus, there aren't cases for comparison with the otherresearches results, but some research done on the two other treatments, i.e., sand and straw on other species, which are discussed below.

Table 1. Analysis of variance split-plot in a randomized complete block design

Sources of Changes	Degree of freedom	Squares mean						
		Percent of establishment	Root fresh weight	Root dry weight	Plant height	Aerial dry yield	Fresh biomass weight	Dry biomass weight
Block	2	7.5 ns	5.126 ns	12.871 ns	9.052 ns	3.319 ns	26.562 ns	568.859 ns
Environment	1	7.5 ns	0.55 ns	0.166 ns	11.685 ns	2.449 ns	884.315 ns	1442.425 ns
The first error	2	158.611	10.31	5.709	3.224	3.731	666.767	937.203
Mulch	4	27.917 ns	516.382**	368.127 **	134.113 **	35.677**	14923.744 **	3138.792*
Mulch× Environment	4	8.657 ns	8.318 ns	11.966 ns	4.082 ns	0.531 ns	526.949 ns	931.77 ns
Experimental error	16	12.454	24.853	14.953	2.333	0.461	695.867	870.987
CV (%)		3.91	11.58	12.73	4.65	5.59	10.54	19.84

* and ** significant at a confidence level of 5%, and 1%, respectively.

Continue Table 1. Analysis of variance split-plot in a randomized complete block design

Sources of Changes	Degree of freedom	Squares mean				
		Stem fresh weight	Stem dry weight	Leaf fresh weigh	Leaf dry weight	Leaf area of a plant
Block	2	39.804 ns	82.294 ns	67.012 ns	705.41 ns	155464.366 ns
Environment	1	163.835 ns	111.828 ns	294.897 ns	855.546 ns	173415.05 ns
The first error	2	257.403	380.738	166.852	381.087	378293.637
Mulch	4	3908.65**	2653.422**	2412.441**	347.575**	1872475.755**
Mulch× Environment	4	327.436 ns	231.184 ns	65.495 ns	7.059 ns	40296.546 ns
Experimental error	16	288.862	226.623	152.177	37.091	87381.84
CV (%)		15.9	18.64	12.29	15.17	22.34

- Percentage of plant establishment

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed the effect of any of the sources of variance analysis table wasn't significant (P <0.05) (Table 1). So, it can be concluded that there was no significant difference between the environment and the different treatments in terms of the average percentage of the establishment. Pearson correlation analysis between the percentage of plant establishment with other measured characteristics of the soil and the plant showed that the percentage of plants establishment with electrical conductivity and pH had a moderate negative correlation (-0.4<r<-0.6). With water use efficiency, plant dry weight and moisture content had a moderate positive correlation (0.4<r<0.6). The results of Orikiriza*et al.*, (2009), Silva et al. (2020)and Sharma and Bhardwaj (2017) indicated a significant and positive impact of super-absorbent on the establishment and aerials biomass of nine species of trees. According to Li *et al.*, (2004) and Song et al. (2019), the effects of stabilization of sand and restore the species diversity cryptogam and soil fertility in the desert, Tengger, north China, showed that re-vegetation leads to improve the environmental conditions and thus the establishment and release of cryptogams on the dunes Tengger. Padilla *et al.*, (2009) in a study as the selection of species in revitalizing arid brush-lands concluded that the highest amount of survival was for legumes and followed by leafless species and brushes C_4, attributes that are considered to maximize the use of resources in cleared areas and unfertilized, while reducing the waste of water. Therefore, the selection of species with meddle sequence along these featuresmust be considered for successful restoration. Esmaeilpour (2012) and Silva et al. (2020) in a study entitled effect of super-absorbent polymer and mycorrhizal inoculation on the establishment of seedlings several species, showed that they have a great impact on the establishment of seedlings.

- Plant height

The results of experimental error normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant ($P<0.01$) (Table 1). Results mean comparison the effect of mulch on heightshowed that plant height was significantly higher than other treatments in the sand treatment (GanjiKhorramdel, and Keykhaee, 2018). Straw treatments, biological hydrogel, and PLANTBAC also had not significantly different in terms of plant height from the controls (Figure 3). Pearson correlation analysis between plant height and other characteristics of the soil and plant showed that the average height of the plant with the pH had a moderate negative correlation ($-0.4<r<-0.6$) and a moderate positive correlation ($0.4<r<0.6$) with aerial dry weight and dry and freshweight a plant. A strong positive correlation ($0.6<r<0.8$) with the water use efficiency and a very strong positive correlation with aerialdry yield ($0.8<r$). Results Gush *et al.*, (2006), Benabderrahim et al. (2018) and Verma et al. (2018) and Benabderrahim et al (2018)as the effect of polyethylene mulch and straw mulch, showed that mulch of straw (wheat or rice) improved the plant height as compared to control (Song et al., 2019).

- Dry yield of aerial parts

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant ($P<0.01$) (Table 1). A comparison of the average effect of mulch on yield of aerial dry indicated that all treatments showed a significant difference to the control (Benabderrahim et al., 2018; Song et al., 2019). The highest yield of aerial dry was obtained in the sand treatment and the lowest in the straw treatment after the control (Figure 4). Pearson correlation analysis between leaf area of a plant with other measured characteristics of the soil and the plant showed that the leaf area of a plant had moderate negative correlation ($-0.4<r<-0.6$) with the EC and sodium. The weak positive correlation ($0.2<r<0.4$) with the percentage of establishment and weak negative correlation ($-0.2<r<-0.4$) with the sodium adsorption ratio. Aerial dry yield positively was correlated to the organic matter of root, leaf area and fresh weight of a plant, leaf dry weight, aerial fresh weight, fresh biomass weight, storage, and sequestration carbon and soil organic matter, aerial dry yield, and leaf fresh weight ($0.4<r<0.6$). With a plant dry weight, aerial dry weight, and the percentage of mycorrhizal had a strong positive correlation ($0.6<r<0.8$) and a strong negative correlation ($-0.8<r$) with pH. The water use efficiency and height had a very strong positive correlation ($0.8<r$). Results Gush *et al.*, (2006), Silva et al. (2020), El–Metwally et al. (2021)as the effect of polyethylene mulch and straw mulch showed that mulch of straw (wheat or rice) have improved the stem and pod yield as compared to the control.

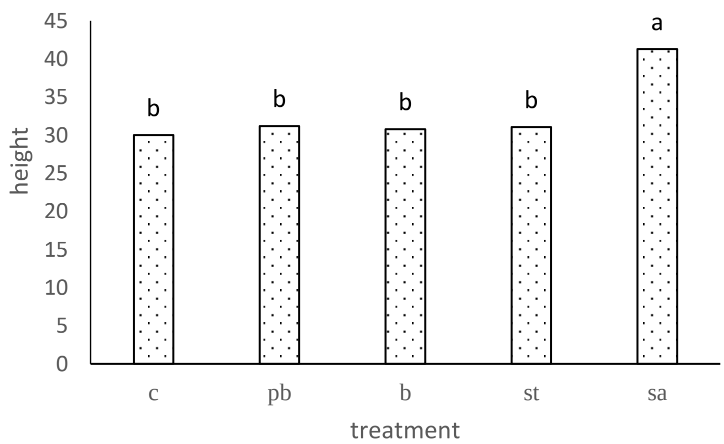

Figure 3. Effect of different treatments on height

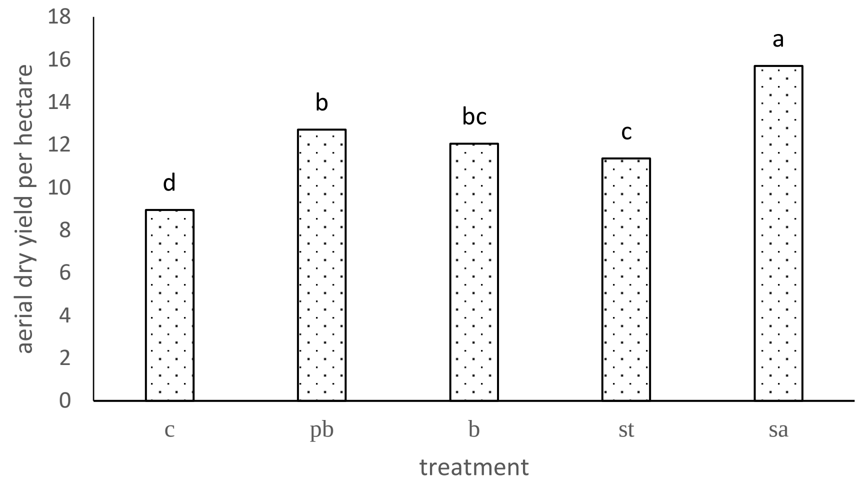

Figure 4. Effect of different treatments on aerial dry yield

- Freshbiomass weight

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant (P<0.01) (Table 1). A comparison of the average effect of mulch on fresh biomass weight showed there was a significant difference in the two PLANTBACand sand treatment plants to the control (El–Metwally et al., 2021; Orikiriza*et al.*, 2009, Azimi, 2018; GanjiKhorramdel, and Keykhaee, 2018;Kianian, 2019). The results also showed that both treatment bio- hydrogel and straw were not significantly different from control. The highestfresh biomass weight belonged to PLANTBAC (Figure 5). Pearson correlation analysis between freshbiomass weight with the other measured characteristics of the soil and the plant showed that fresh biomass weight has a moderate negative correlation (-0.4<r<-0.6)withsodium adsorption ratio, the amount of sodium, and pH.It had a weak negative correlation (-0.2<r<-0.4) with wsc. With sequestration,storage, and soil organic carbon, the average total organic matters aerial, root organic matters, magnesium, mycorrhizal percent, dry weight a plant and fresh weight of root, aerialdry yield, and leaf dry weight positive had amoderate positive correlation (0.4<r<0.6). With a fresh and dry weight of aerial, leaf fresh weight had a very strong positive correlation (-0.8<r) and a strong positive correlation (0.6<r<0.8) withthe area of the plant leaf (Benabderrahim et al., 2018; Song et al., 2019).

- Dry biomass weight

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant (P<0.05) (Table 1). A comparison of the average effect of mulch on the weight of dry biomass showed that only PLANTBAC treatment showed a significant difference with the control(Silva et al., 2020; Azimi, 2018; Orikiriza*et al.*, 2009, GanjiKhorramdel, and Keykhaee, 2018;Kianian, 2019; El–Metwally et al., 2021). The results also showed that three treatments, sand, straw, and bio-hydrogel had no significant difference with the control. The greatest amount of dry biomass weight belonged to the PLANTBAC treatment (Figure 6). Pearson correlation analysis between dry biomass weight was with other measured characteristics of the soil and the plant showed that the weight of dry biomass with bulk density, electrical conductivity, sodium adsorption ratio, the amount of sodium, and pH has a moderate negative correlation (-0.4<r<-0.6). Also, the fresh weight leaves a weak positive correlation (0.2<r<0.4). with the fresh weight of leaf, forage ash, dry weight and organic matters of the root, soil organic carbon, the percentage of mycorrhizal, dry and fresh weight of stem, magnesium, average total organic matter of aerial, dry weight of leaf, leaf area a plant, DMD and fresh biomass weight had moderate positive correlation (0.4<r<0.6) (Song et al., 2019).

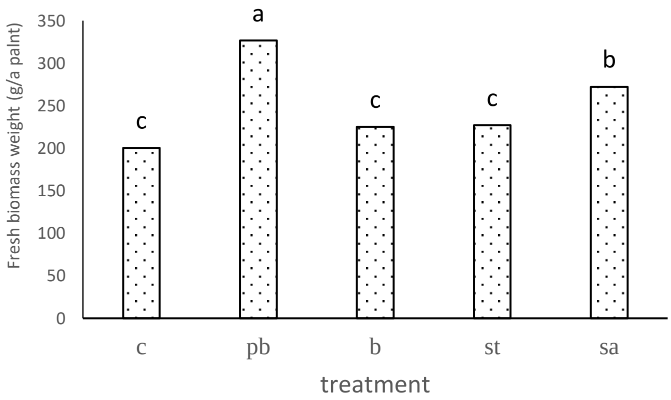

Figure 5. Effect of different treatments on fresh biomass weight.

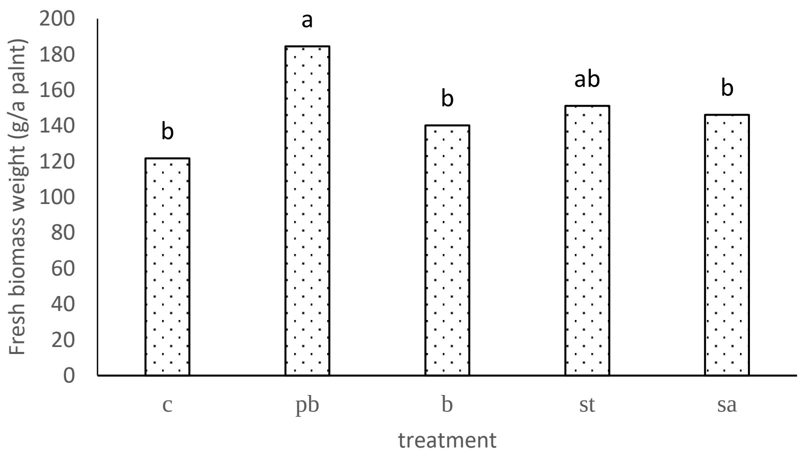

Figure 6. The effect of different treatments on dry biomass weight.

- Root fresh weight

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant (P<0.01) (Table 1). A comparison of the average effect of mulch on the root fresh weight showed that the root fresh weight was significantly higher than the control on all four mulch treatments(Silva et al., 2020; El–Metwally et al., 2021; Orikiriza*et al.*, 2009, Azimi, 2018; GanjiKhorramdel, and Keykhaee, 2018;Kianian, 2019). The results also showed that the highest fresh weight was related to PLANTBAC that was differed from straw and sand treatment in terms of root fresh weight (Figure 7). Pearson correlation analysis between the fresh weight of the root with characteristics measured in the soil and plant showed that the fresh weight of root with calcium and sodium, pH, SAR, and bulk densityhas a moderate negative correlation (-0.4<r<-0.6), with an average total organic material of plant, organic materials of the root, leaf area of a plant, sequestration, storage, organic carbon and soil organic matters, carbon sequestration total plants, the percentage of mycorrhizal, fresh biomass weight, calcium, magnesium a moderate positive correlation (0.4<r<0.6). With leaf organic matters, moisture content, plant carbon, nitrogen, and carbon storage of the plant, a strong positive correlation (0.6<r<0.8), with the root dry weight a very strong positive correlation (0.8<r) and a strong negative correlation with litter organic matters (-0.8<r)(Song et al. 2019).

- Root dry weight

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant (P<0.01) (Table 1). Mean comparison of the effect of mulch on the root dry weight showed that root dry weight was significantly higher than the control in all treatment groups(Song et al. 2019; El–Metwally et al., 2021; Orikiriza*et al.*, 2009, Azimi, 2018; GanjiKhorramdel, and Keykhaee, 2018;Kianian, 2019). The results also showed that the highest dry weight was related to PLANTBAC that was differed from straw and sand treatment in terms of root dry weight (Fig. 8). Pearson correlation analysis between root dry weight with other characteristics in the soil and plant showed that root dry weight with calcium and sodium and bulk density had a moderate negative correlation (-0.4<r<-0.6), with an average total organic material of plant, root organic materials, leaf area of a plant, sequestration, storage and soil organic matters, carbon sequestration total plant, mycorrhizal percent, dry biomass weight, calcium, magnesium, a moderate positive (0.4<r<0.6). Also, with leaf organic matters, moisture content, plant carbon, nitrogen, and carbon storage of total plant, a strong positive correlation (0.6<r<0.8), with the dry weight of the root a very strong positive correlation (0.8<r) and a strong negative correlation with litter organic materials (-0.8<r)(Silva et al., 2020).

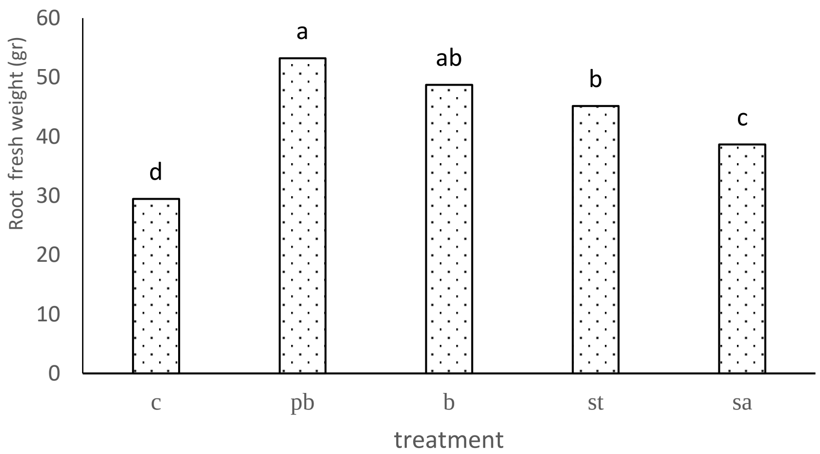

Figure 7. The effect of different treatments on root fresh weight.

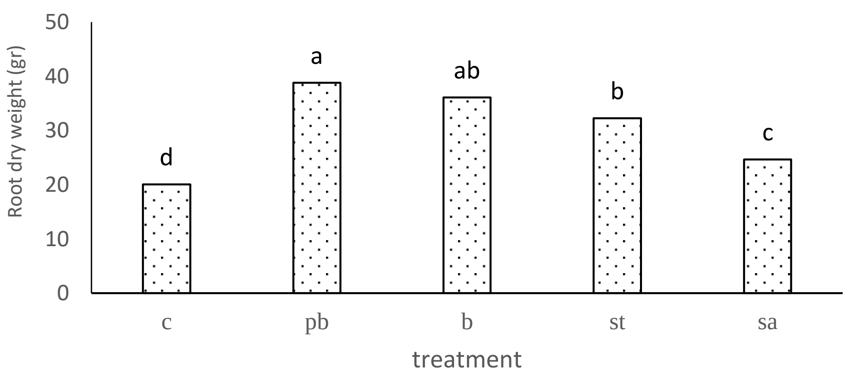

Figure 8. Effect of different treatments on root dry weight

- Stem fresh weight

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant (P<0.01) (Table 1). A comparison of the average effect of mulch on shoot fresh weight showed that the two treatments PLANTBAC and sand had the greatest shoot fresh weight and had a significant difference with the control (El–Metwally et al., 2021; Orikiriza*et al.*, 2009, Azimi, 2018; GanjiKhorramdel, and Keykhaee, 2018;Kianian, 2019; AbediKuhpai, and Sohrab, 2004). Also, results showed that the two treatments straw and bio-hydrogel had no significant difference in terms of the dry weight of the shoot (Figure 9). Pearson correlation analysis between shoot fresh weight with other characteristics in the soil and plant showed that shoot fresh weight with SAR, sodium, and pH had a moderate negative correlation (-0.4<r<-0.6) and with the storage and carbon sequestration in soil and root organic matters a weak positive correlation (0.2<r<0.4). With the water use efficiency, average total organic materials of plant, mycorrhizal percent, dry biomass weight and shoot dry yield had a moderate positive correlation (0.4<r<0.6). The leaf area of a plant has a strong positive correlation (0.6<r<0.8), with the leaf fresh weight, shoot dry weight, and fresh biomass weight a very strong positive correlation (0.8<r)(Song et al. 2019; Silva et al., 2020).

- Stem dry weight

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant (P <0.01) (Table 1). Mean comparison of the effects of mulch on shoot dry weight showed that sand treatments and PLANTBAC have the highest dry weight and had a significant difference with the control(Song et al. 2019; Orikiriza*et al.*, 2009, Azimi, 2018; GanjiKhorramdel, and Keykhaee, El–Metwally et al., 2021; 2018;Kianian, 2019). The results also showed that both straw treatment and bio-hydrogel had no significant difference in terms of shoot dry weight with the controls (Fig. 10). Pearson correlation analysis showed a moderate negative correlation between shoot fresh weight with potassium, SAR, sodium, and pH (-0.4<r<-0.6). Also, it showed a moderate positive correlation with phosphorus, water use efficiency, root organic materials, plant's height, average total organic materials of plant, mycorrhizal percent, the weight of dry biomass, and leaf dry weight (0.4<r<0.6). With plant leaf area and shoot, the dry yield had a strong positive correlation (0.6<r<0.8), with the fresh weight of leaf, stem fresh weight, and biomass fresh biomass weight a very strong positive correlation (0.8<r)(Silva et al., 2020).

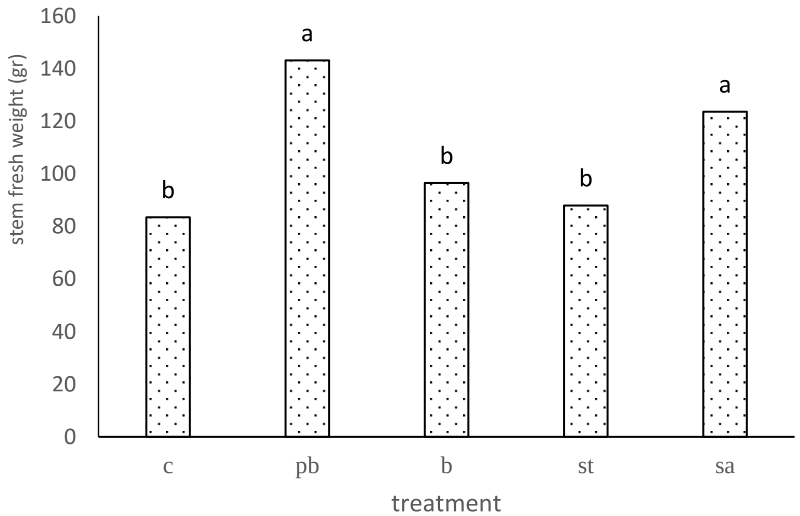

Figure 9. The effect of different treatments on stem fresh weight.

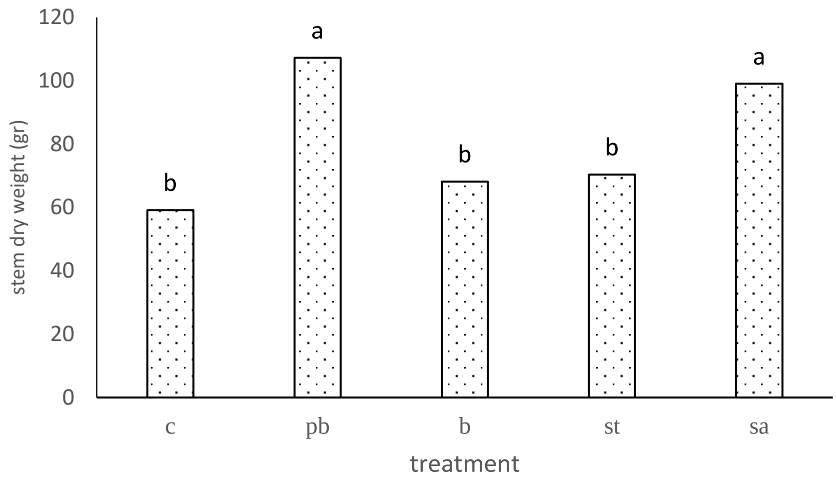

Figure 10. Effect of different treatments on stem dry weight.

- Leaf fresh weight

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant (P<0.01) (Table 1). Mean comparison of the effect of mulch on leaf fresh weight showed that both beck plant treatment and sand were significantly more than the control. While the bio-hydrogel treatment and straw were not significantly different from the control(Orikiriza*et al.*, 2009, Azimi, 2018; GanjiKhorramdel, and Keykhaee, 2018;Kianian, 2019; El–Metwally et al., 2021). The maximum weight of the leaf fresh was observed in the PLANTBAC (Figure 11). Pearson correlation analysis between the fresh weight of leaves and other characteristics measured in the soil and plant showed that leaf fresh weight with an average total organic material of plant, leaf dry weight, average total organic materials of the shoot, stem organic materials, and leaf area a plant had a moderate positive correlation (0.4<r<0.6), with a fresh and dry weight of stem and fresh biomass weight any plant a very strong positive correlation (0.8<r). Also, it showed a weak positive correlation with the weight of dry biomass (0.2<r<0.4) and a moderate negative correlation with the WSC (-0.4<r<-0.6)(Song et al. 2019).

- Leaf dry weight

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant (P<0.01) (Table 1). Mean comparison of the effect of the mulch on dry weight showed that two PLANTBAC treatments and sand were significantly more than the control(Teame et al., 2017; Orikiriza*et al.*, 2009, Azimi, 2018; GanjiKhorramdel, and Keykhaee, 2018;Kianian, 2019). While the bio-hydrogel treatment and straw were not significantly different from the control. Maximum leaf dry weight was observed in the PLANTBAC treatment (Figure 12). Correlation analysis between leaf dry weight with other characteristics of the soil and the plant showed that leaf dry weight with shoot dry yield, fresh and dry weight of shoot, water use efficiency, dry weight of a plant, the percentage of mycorrhizal, fresh and dry biomass weight a plant, leaf fresh weight, alkaloid, DMD and moisture content had a moderate positive correlation (0.4<r<0.6), a strong positive correlation with the leaf area of a plant, (0.8<r). Also, it showed a moderate negative correlation with sodium, pH, electrical conductivity, percent sand, zinc, bulk density, and sodium adsorption ratio (-0.4<r<-0.6).

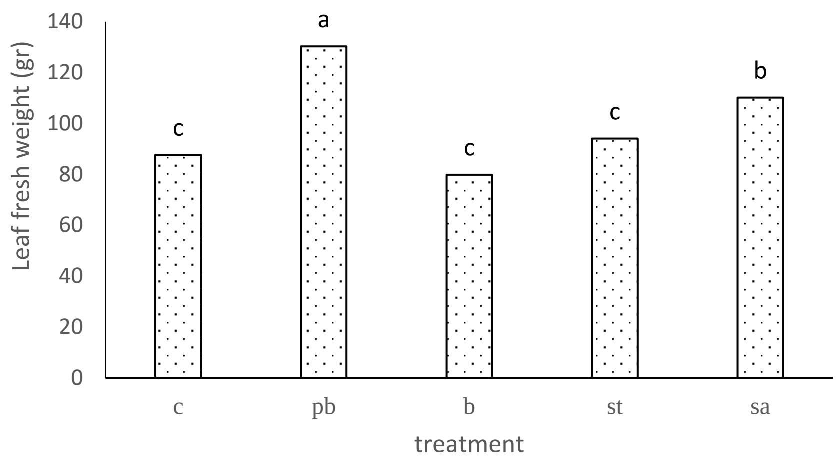

Figure 11. Effect of different treatments on fresh weight of leaf.

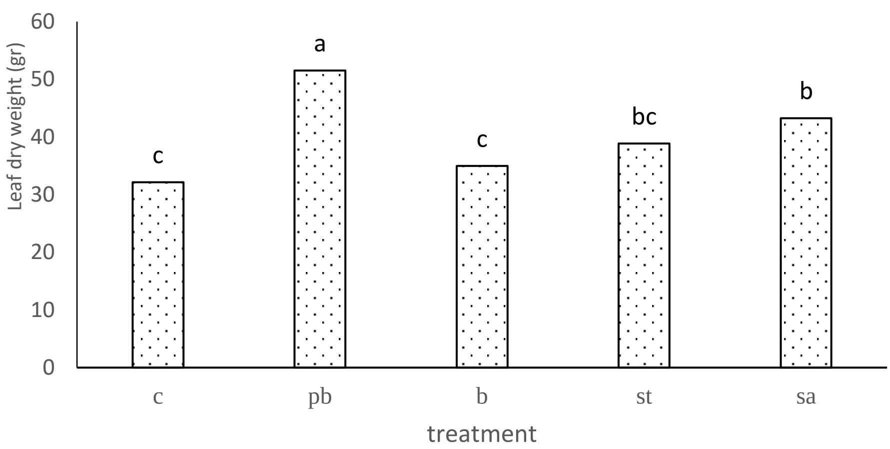

Figure 12. Effect of different treatments on leaf dry weight

- Leaf area of a plant

The results of experimental errors normality by all four tests confirmed the data normality. Analysis of variance showed that the effect of mulch was significant (P<0.01) (Table 1) (Teame et al., 2017; Orikiriza*et al.*, 2009, Azimi, 2018 and Kianian, 2019). A comparison of the average effect of mulch on the area of plant leaves showed there was a significant difference in three PLANTBAC treatments, sand, and bio-hydrogel with the control (GanjiKhorramdel, and Keykhaee, 2018; El–Metwally et al., 2021; AbediKuhpai, and Sohrab, 2004). Results also showed that the leaf area of a plant had no significant difference in the straw treatments. Most of the leaf area per plant was obtained in the PLANTBAC treatment (Figure 13). Pearson correlation analysis between leaf area of a plant with other measured characteristics of the soil and the plant showed that the leaf area of a plant was negatively correlated with bulk density, sodium adsorption ratio, the amount of sodium, and pH (-0.4<r<-0.6). With magnesium had a weak positive correlation (0.2<r<0.4) and to the organic matters leaves, water use efficiency, DMD, mycorrhizal percent, the weight of dry biomass a plant and fresh and dry weight root, storage and sequestration carbon, soil organic carbon, shoot dry yield and leaf fresh weight a moderate positive correlation (0.4<r<0.6). Also, the fresh and dry weight of stem, leaf dry weight, and fresh biomass had a strong positive correlation (0.6<r<0.8)(Silva et al., 2020).

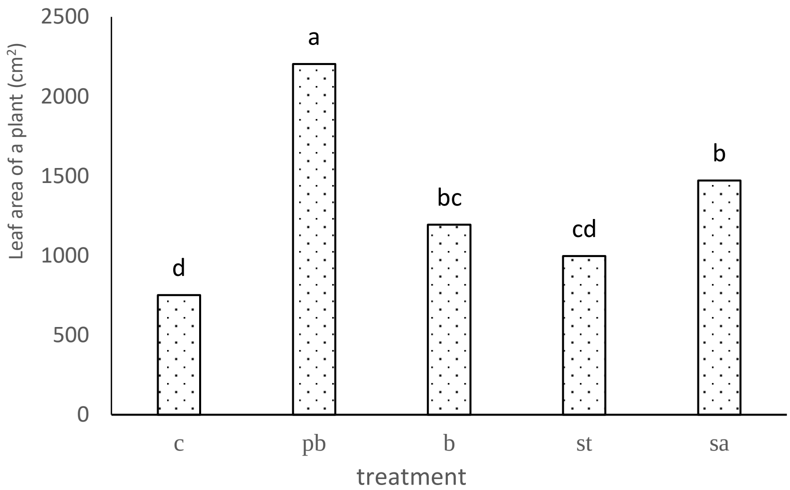

Figure 13. Effect of different treatments on a leaf area.

Conclusion

The process of desertification and soil degradation leads to pollution and the tremendous waste of water resources, soil, and plant. Also, water resources and poor chemical and physical characteristics of the soil are the most important factor limiting the establishment and growth of plant species in arid and desert areas. Given that, oil mulches in our country and some other countrieshave environmental impacts and high transportation costs, they can be replaced with new materials and compatible with nature with less cost. Therefore, we can usesuper-absorbents and amendments, which can improve the success rate of seedling establishment and water use efficiency. In this studywas studied the effectiveness of bio-hydrogel (biological mulch), the herbaceous layer of PLANTBAC, sand, and barley straw along with rainwater harvesting techniques in the micro-catchmentscale (inter-row system) on some characteristics of desert plant *Nitrariaschoberi* including percentage survival (establishment), biomass, growth rate (leaf area and height), phenolic compounds and the alkaloidof totalplant and fresh and dry weight of roots and aerials andaerials dry yield in treatments and various iterations.

Based on the analysis results of the effect of mulch on phenol, alkaloid, and the percentage of plantestablishment, it can be concluded that there is no significant difference between the environment and the different treatments in terms of the amount of phenol, i.e., we can propose each treatment concerning the price for the region. For plant height, plant height in the sand treatment was significantly higher than in other treatments. This suggests that the treatment than other factors is better to preserve moisture in the soil for plants. Straw treatments, biological hydrogel, and PLANTBAC also had no significant difference in plant height with the control. According to the results of the effect of the mulch on aerial dry yield, treatment groups had nosignificant difference from the control. The highest yield of aerialdry was in the sand treatment and the lowest in the straw after the control treatment. According to the analysis of the effect of mulch on a leaf area, it can be concluded that the three treatments PLANTBAC, sand, and bio-hydrogel had a significant difference from the control. Results also showed that the leaf area of the plant had no significant difference in the straw treatment. Most of the leaf area per plant was achieved in the treatment PLANTBAC, which can be proposed for the region. Then sand and bio-hydrogel are recommended.

Results of the effect of mulch on fresh biomassweight showed that the treatment PLANTBAC and sand had a significant difference with the control. The results also showed that both straw treatment and bio-hydrogel were not significantly different from the control. The highest fresh biomass weight

belonged to the PLANTBAC, which can be proposed for the region. Then sand is recommended. Results of the effect of mulch on dry biomass weightshowed that the onlyPLANTBACtreatment has a significant difference from the control. The results also showed that three treatments, sand, straw, and bio-hydrogel had no significant difference with the control in terms of dry biomass weight. The greatest amount of dry biomass weight belonged to the PLANTBAC treatment, it is probably due to the absorption of more moisture in the soil and the presence of its nutrients which absorb by plants. Hence, they can be proposed for the region. According to the analysis of the effect of mulch on the fresh and dry weight of root, it can be concluded that all four treatments were significantly higher than the control. The results also showed that the highest fresh weight and dry of the root was related to the treatment PLANTBAC, which had a difference with the straw treatment and sand in terms of fresh weight and dry of the root, it is probably due to the absorption of more moisture in the soil and the presence its nutrients which absorb by the plant. Hence, it can be proposed for the region. According to the analysis of the effect of mulch on the fresh and dry weight of stem, it can be concluded that two PLANTBAC and sand had the highest fresh weight and dry of stem and had a significant difference with the control. The results also showed that both straw treatment and bio-hydrogel had no significant difference with the control in terms of fresh weight and dry of the stem. This shows that the two treatments are better than other treatments in absorbing adequate moisture and food (due to a higher concentration of nutrient and water uptake). Hence, they can be proposed for the region. Results of the effect of mulch on fresh weight and dry of leafshowed that two PLANTBACtreatments and sand were significantly more than the control. While both treatmentsstraw and bio-hydrogel had no significant difference with the control in terms of fresh weight and dry of the leaf. Maximum leaf dry weight was observed in the PLANTBAC treatment. This shows that the two treatments are better than other treatments in absorbing adequate moisture and food (due to a higher concentration of nutrient and water uptake). Hence, they can be proposed for the region.
Thus, concerning the effectiveness of the effects of mulches present on a variety of factors, soil, and soil moisture and the price of each, availability and terms of area, they can be used to establish plants in desert areas and by controlling dust and dunes, soil erosion, etc. the areas are restored.

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References

-AbediKuhpai, J., and Sohrab, F., 2004. Assessment of Superabsorbent Polymers Application on WaterHolding and Potential of Three Different Soils. Iran J. Polymer Sci. Tech., 3(17): 163-173.

-Ahmadi, H., 2019. Recognition criteria deserts of Iran. Researches of the Second National Conference on desertification and different methods of desertification, Forests and Rangelands Research Institute.

-Ahmadi, M., &Saeidi, H.,2018. Genetic diversity and structure of *Capparisspinosa* L. in Iran as revealed by ISSR markers. Physiology and Molecular Biology of Plants, 24(3), 483-491.

-Allahdadi, A. Ghamsari, B. M. Akbari, Gh. A. and ZohorMehr, M. J., 2005. The effect of different amounts of polymer A200 and different irrigation levels on the growth and yield of maize. The third training course and specialized seminar for agricultural use of superabsorbent hydrogels. Iran Polymer and Petrochemical Institute. Tehran.

-Ashraf, U., Chaudhry, M. N., Ahmad, S. R., Ashraf, I., Arslan, M., Noor, H., &Jabbar, M., 2018. Impacts of climate change on *Capparisspinosa*L. based on ecological niche modeling. *PeerJ*, 6, e5792.

- Azimi, R., Heshmati, G.A., Kianian, M.K., Hossein jafari, S. and Zakeri, D., 2018. Role of Plant Species and Ecological Patches in Conserving and Fixing Natural Lands′ Soil Using Landscape Functional Analysis (LFA) (Case Study: Dehbar Rangeland, Torghabeh, Mashhad, Iran). Journal of rangeland science, Volume 8, Issue 2 (4), Pages 166-175.

- Azimi, R., 2017. Effects of Drought Stress and Mycorrhiza on Viability and Vegetative Growth Characteristics of *Ziziphoraclinopodioides* Lam. Journal of Rangeland Science.

- Azimi, R., 2016. Studying *Arbuscular Mycorrhiza* Symbiotic Effects on Establishment and Morphological Characteristics of *Bromuskopetdaghensis* in Cadmium Contaminated Soil, Taiwan Water Conservancy, Vol. 64, No. 3.

-Azimi, R., 2016. Investigating the Germination Characteristics of *Poteriumsanguisorba*Seeds under the Influence of Thermal Treatments for Pasture Establishment. *Journal of Rangeland Science*, Vol. 6, No. 1.

- Azimi, R., 2019. Investigation of the TiO2 nanoparticles effects on seed germination characteristics of *Ziziphoraclinopodioides* Lam., plant breeding and seed science, 79.

- Azimi, R., 2018. Mycorrhiza inoculation effects on seedling establishment, survival and morphological properties of *Ziziphoraclinopodioides* Lam. Journal of plant nutrition. USA.

-Bearce, B.C., McCollum, R.W., 1977. A comparison of peat lite and non-composted hardwood-bark mixes for use in the pot and bedding-plant production and the effect of a hydrogel on their performance. Flor. Rev. 161, 21-23.

-Benabderrahim, M. A., Elfalleh, W., Belayadi, H., & Haddad, M., 2018. Effect of date palm waste compost on forage alfalfa growth, yield, seed yield and minerals uptake. *International Journal of Recycling of Organic Waste in Agriculture*, 7(1), 1-9.

-Boatright, J.L., Balint, D.E., Mackay, W.A., Zajicek, J.M., 1997. Incorporation of a hydrogel into annual landscape beds. Journal of Environmental Horticulture 15, 37-40.

-Bowman, D.C., R.Y. Evans, and J.L. Paul., 1990. Fertilizer salts reduce hydration of polyacrylamide gel and affect the physical properties of gel-amended container media. J. Amer. Soc. Hortsci. 115(3): 382-386.

- Callaghan, T.V., Abdelnour, H., Lindley, D.K., 1988. The environmental crisis in Sudan: the effect of water-absorbing synthetic polymers on tree germination and early survival. Journal of Arid Environments 14, 301- 317.

- Callaghan, T.V., Lindley, D.K., Ali, O.M., Abdelnour, H., Bacon, P.J., 1989. The effect of water-absorbing synthetic polymers on the stomatal conductance, growth, and survival of transplanted Eucalyptus microtheca seedlings in Sudan. Journal of Applied Ecology 26, 663-672.

- Castro, J., Zamora, R., Hóndar, J. A., and Gómez, J. M., 2002. The use of shrubs as nurse plants: a new technique for reforestation in Mediterranean mountains, Rest. Ecol, 10, 297–305.
-DehghanSalmasi, M. J., 1994. Overview of the Iran range management. Journal of forest and rangeland, 21.
-El–Metwally, I.; Geries, L.; Saudy, H., 2021. Interactive effect of soil mulching and irrigation regime on yield, irrigation water use efficiency and weeds of trickle–irrigated onion. *Arch. Agron. Soil Sci.* 68, 1103–1116.
- El-Sheikh, Mohamed A., Ghanim A. Abbadi, Pietro M. Bianco, 2010. Vegetation ecology of phytogenic hillocks (Nabkhas) in coastal habitats of Jal Az-Zor National Park, Kuwait: Role of patches and edaphic factors, Flora 205 (2010) 832–840.
-Esmaeilpour, Y., 2012. Effect of super-absorbent polymer and mycorrhizal inoculation on the establishment of seedlings of several species. Ph.D. thesis desertification. Natural Resources Faculty of Tehran University. 150 pages.
-Fatahi, A., SafarianZengir, V., Sobhani, B., Kianian, M.K. and A. Ghahremani, 2022. Assessment and zoning of suitable climate for economic development of cultivation of Sunflower (*Helianthus annuus*) garden crop (Ardabil Province, Iran). Eur. J. Hortic. Sci.
- GanjiKhorramdel, N and Keykhaee, F., 2018. The use of super-absorbent polymer PR 3005 A to the success of irrigation projects in arid and semi-arid areas. The first Conference on ways to prevent waste of national resources of Tehran.
-Gehring, J.M., Lewis, A.J., 1980. Effect of hydrogel on wilting and moisture stress of bedding plants. Journal of American Society of Horticultural Science 105, 511-513.
-Hasanpori, R., Sepehry, A., &Barani, H., 2020. Effect of Rangeland Conversion to Dryland Farming on Soil Chemical Properties (Case study: Kian rangelands, Lorestan, Iran). *Journal of Rangeland Science*, 10(1), 49-56.
-Huttermann, A., Zommorodi, M., Reise, K., 1999. Addition of hydrogels to the soil for prolonging the survival of *Pinushalepensis* seedlings subjected to drought. Soil and Tillage Research 50, 295-304.
-Iqbal, R.; Raza, M.A.S.; Saleem, M.F.; Khan, I.H.; Ahmad, S.; Zaheer, M.S.; Aslam, M.U.; Haider, I., 2019. Physiological and biochemical appraisal for mulching and partial rhizosphere drying of cotton. *J. Arid Land*, 11, 785–794.
- Jafari, Z. and Kianian, M.K., 2016. Floristic Composition, Life Forms and Geographical Distribution (Case Study: Lashgardar Rangelands of Malayer, Iran), Journal of Environmental Science and Technology.
-Javaid, M.M.; AlGwaiz, H.I.M.; Waheed, H.; Ashraf, M.; Mahmood, A.; Li, F.-M.; Attia, K.A.; Nadeem, M.A.; AlKahtani, M.D.F.; Fiaz, S., 2022. Ridge-Furrow Mulching Enhances Capture and Utilization of Rainfall for Improved Maize Production under Rain-Fed Conditions. *Agronomy*, 12, 1187.
-Kabiri K., FaraJi- Dana S., Zohuriaan – Mehr M.J., 2015. "Novel sulfobetaine – sulfonic Acid-contained super swelling Hydrogels". Polym. Adv. Technol., 16:659-666.
-Kader, M.A.; Senge, M.; Mojid, M.A.; Ito, K., 2017. Recent advances in mulching materials and methods for modifying soil environment. *Soil Tillage Res.*, 168, 155–166.
-Khajeddini, M. A., Dadpour, M.R., Khodaverdi, M. and Naghiloo, S., 2012. The GC-MS analyses of the n-hexane extract of *Nitrariaschoberi* L., its total phenolics, and in vitro antioxidant activity. International Journal of Agriculture and Crop Sciences.
- Kianian, M.K., 2022. World Deserts and Kavirs (Iran and Other Countries). Lambert academic publishing, Germany.

- Kianian, M.K., 2019. Studying Environmental Factors on Halophyte and Xerophyte Plants Establishment in Desert Region (Case Study: Semnan, Iran). International Journal of Agriculture and Environmental Research: 5 (2).
- Kianian, M.K., 2012. Studying surface properties of desert pavements and their relation to soil properties and plant growth in Hajaligholi playa, Iran, Arabian Journal of Geosciences,
- Li, Xinrong, 2004. Cryptogam diversity and formation of soil crusts in a temperate desert. Annals of arid zone 43(3):335-353.
-Li, C.; Wang, C.; Wen, X.; Qin, X.; Liu, Y.; Han, J.; Li, Y.; Liao, Y.; Wu, W., 2017. Ridge-furrow with plastic film mulching practice improves maize productivity and resource use efficiency under the wheat-maize double-cropping system in dry semi-humid areas. *Field Crops Res.*, 203, 201–211.
-Li, Q.; Li, H.; Zhang, S., 2018. Yield and water use efficiency of dry land potato in response to plastic film mulching on the Loess Plateau. *Acta Agric. Scand. Sect. B Soil Plant Sci.* 68, 175–188.
-Luo, L.; Hui, X.; He, G.; Wang, S.; Wang, Z.; Siddique, K.H.M., 2022. Benefits and Limitations to Plastic Mulching and Nitrogen Fertilization on Grain Yield and Sulfur Nutrition, Multi-Site Field Trials in the Semiarid Area of China. *Front. Plant Sci.* 13, 799093.
- Milton, S. J., W. R. Dean, M. A. du Plessis, and W. R. Siegfried, 1994. A conceptual model of arid rangeland degradation. Bioscience 44: 70–76.
-Orikiriza, L., J., B., Agaba, H., Tweheyo, M., Eilu, G., Kabasa, J., D., Hüttermann, A., 2009. Amending soils with hydrogels increases the biomass of nine tree species under non-water stress conditions. Clean, 37 (8), 615–620.
- Padilla, Francisco M., Juan de Dios Miranda, Rafael Ortega, Manuel Hervás, Joaquín Sánchez and Francisco I. Pugnaire, 2011. Does shelter enhance early seedling survival in dry environments? A test with eight Mediterranean species. *Applied Vegetation Science*, Vol. 14, No. 1, 31-39
-Pamuk, G.S., 2004. Controlling water dynamics in Scots pine (*Pinussylvestris* L.) seeds before and during seedling emergence. Ph. D. Dissertation, Swedish University of Agricultural Sciences, Umea.
- Pazhohesh, M., 2008. Effects of various super absorbent concentrations on runoff volume in slopes and various intensity of simulated rainfall in Sharekord plain, Desert Journal, No.12: 121-128.
-Rabiee, A., 2011. Preparation of anionic polyelectrolyte based on acrylamide as soil stabilizer. Journal of Polymer Science and Technology, No. (4): 291 -300.
-Rashid, M.A.; Zhang, X.; Andersen, M.N.; Olesen, J.E., 2019. Can mulching of maize straw complement deficit irrigation to improve water use efficiency and productivity of winter wheat in North China plain? *Agric. Water Manag*, 213, 1–11.
-Rezaee, S., 2009. Comparison of the effects of poly-lattice polymer and oil mulch on seed germination and plant establishment to stabilize dunes. Journal of Scientific- Research range and desert research of Iran, 16 (1): 136- 124.
- Save, R., Pery N., Marfa, O., Serrano, L., 1995. The effect of hydrophilic polymer on plant and water status and survival of pine seedlings. Hort Technology 5, 141- 143.
-Sharifi Rad, M., Sharifi Rad, J., Heshmati, Gh. A., Miri, A. and Jyoti Sen, D., 2016. Biological Synthesis of Gold and Silver Nanoparticles by *Nitrariaschoberi* Fruits. American Journal of Advanced Drug Delivery.
-Sharifi Rad., J., HoseiniAlfatemi., S. M. Sharifi Rad., M. and Iriti., M., 2014. Free Radical Scavenging and Antioxidant Activities of Different Parts of *Nitrariaschoberi* L. TBAP, 4, 44-51.
-Sharifi-Rad., J., Hoseini-Alfatemi., S.M., Sharifi-Rad., M., Teixeira da, S. and Jaime, A., 2015. Antibacterial, antioxidant, antifungal, and anti-inflammatory activities of crude extract from *Nitrariaschoberi* fruits. Biotech., 5, 677–684.
-Sharma, R. and Bhardwaj, S., 2017. Effect of mulching on soil and water conservation: A review. *Agric. Rev.*, 38, 311–315.

- Sheikh, VahedBardi, 2014. Pamphlet of management and exploitation of unconventional waters, Faculty of Natural Resources, Gorgan University.
30. Shilev, S., 2020. Plant-Growth-Promoting Bacteria Mitigating Soil Salinity Stress in Plants. *Applied Sciences*, 10(20), 7326.
-Silva, G.H.; Cunha, F.F.; Morais, C.V.; Freitas, A.R.J.; Silva, D.J.H.; Souza, C.M.D., 2020. Mulching materials and wetted soil percentages on zucchini cultivation. *Ciênc. Agrotecnol.* 44, e006720.
-Song, X.; Sun, R.; Chen, W.; Wang, M., 2019. Effects of surface straw mulching and buried straw layer on soil water content and salinity dynamics in saline soils. *Can. J. Soil Sci.* 100, 58–68.
- Specht, A., Harvey-Jones, J., 2000. Improving water delivery to the roots of recently transplanted seedling trees: the use of hydrogels to reduce leaf and hasten root establishment. Forest Research 1, 117-123.
-Teame, G., Tsegay, A., &Abrha, B., 2017. Effect of organic mulching on soil moisture, yield, and yield contributing components of sesame *(Sesamumindicum*L.). *International journal of agronomy*, 15: 1-7.
-Tongway, D. J. and J. A. Ludwig, 1996. Rehabilitation of Semiarid Landscapes in Australia. I. Restoring Productive Soil Patches, Restoration ecology journal. Volume 4, Issue 4, December 1996 Pages 388–397.
-Verma, V.K.; Jha, A.K.; Verma, B.C.; Nonglait, D.; Chaudhuri, P., 2018. Effect of Mulching materials on soil health, yield and quality attributes of broccoli grown under the mid-hill conditions. *Proc. Natl. Acad. Sci. India Sect. B Biol. Sci.* 88, 1589–1596.
- Wallace, A., Wallace, G.A., 1986. Effect of polymeric soil conditioners on the emergence of tomato seedlings. Soil Science 141, 321-323.
- Wang, X.B., Dai, K., Zhang, D.C., Zhang, X.M., Wang, Y., Zhao, Q.S., 2011c. Dryland maize yields and water use efficiency in response to tillage/crop stubble and nutrient management practices in China. Field Crops Research 120, 47–57.
- Wang, Q.J., Chen, H., Li, H.W., Li, W.Y., Wang, X.Y., McHugh, A.D., 2009b. Controlled traffic farming with no-tillage for improved fallow water storage and crop yield on the Chinese Loess Plateau. Soil and Tillage Research 104, 192–197.
-Yang, Y.; Ding, J.; Zhang, Y.; Wu, J.; Zhang, J.; Pan, X.; Gao, C.; Wang, Y.; He, F., 2018. Effects of tillage and mulching measures on soil moisture and temperature, photosynthetic characteristics and yield of winter wheat. *Agric. Water Manag.* 201, 299–308