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The effect of tree planting on native vegetation in the dust center of southwest Iran

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Abstract:
In order to dust control, 26,000 ha of the dusty center of southwest Iran were stabilized by planting *Prosopis juliflora* in Khuzestan province, Iran from 2015 to 2021. This study was conducted to investigate the effect of tree planting on the richness and diversity of the local plant species and identify the appropriate irrigation methods for tree plantations and increasing the native vegetation cover. In this research, the richness and diversity of plant species and the amount of vegetation production were investigated. During the field survey, a total of 420 fixed plots were established for both tree planting and control sites (without tree planting) in seven areas of Bagan, Hofireh, Shoaimit Faleh, Shoamit Mandil, Sharifiieh, Seyed Sharaf, Mosalemieh, in Ahvaz County, Iran. To achieve the research goal, the plant sampling was first done in both sites within each area. Data were collected for species diversity, species richness, species evenness, dominance and Simpson's and Shannon's diversity indices. An ANOVA (Analysis of variance) was made between seven locations and the T-test was used for comparisons between two sites (tree plantation area and control) within each location. The results of the T-test showed significant differences for all diversity indices between tree plantation and control sites in all areas except for the Mosalemieh. Results showed that irrigation coupled with rainfall had an effective role in increasing plant species diversity of the local vegetation in the deserts and the restoration of fragile pastures. It was concluded that all areas had plenty of native seed banks, and if a suitable substrate is provided for these reserves and enough water is available, the native vegetation could be established.

Keywords: Dust center; Iran; Planting; Native vegetation; Seedling cultivation

Introduction

Desertification was defined in the preamble to the Convention to Combat Desertification (CCD) (UNEP, 1995) as 'land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities'. Desertification has two main components, vegetation degradation, and soil degradation, caused by over cultivation, overgrazing, reduction in tree cover, and poor irrigation management. Desertification is generally reversible until the land is eventually turned into a desert, and can occur anywhere in dry areas and not just on desert fringes (Grainger, 1990). Desertification is a serious environmental problem and it potentially affects 35% of the land surface of the earth and 32% of the human population (Ghrefat, 2011).

Rangelands are ecosystems with various services and functions in addition to providing forage. Among the most important uses that can be made of rangeland are tourism, livestock grazing, and beekeeping (Rahimi Dehcheraghi et al., 2021). Several methods have been used to reduce the rate of desertification. These methods include restoring and fertilizing the land, reforestation, and developing sustainable agricultural practices, and traditional lifestyles. Reforestation helps fix the soil, acts as a windbreaker, enhances soil fertility, and can absorb water during heavy rainfall (Ghrefat, 2011). Therefore, at the potentially retreating xeric limits of forests in the meeting zone of steppe and woodland, afforestation and restoration of natural conditions should be carefully considered. Especially concerns about hydrology and climate should be weighed when making decisions about land use changes (Cao, 2008; Cao et al., 2011; Matyas, 2010). An area equivalent to 737790 ha of the Khuzestan Plain in the southwest of Iran is considered as a dust source (Abbasi, 2021). Dust centers of Khuzestan province have an inferior species richness compared to the northern and eastern regions of the province (including foothills and mountains). A possible explanation for this might be the majority of the dust centers are located in plain areas with fine and somewhat uniform sediments without any ruggedness (Heidarian et al., 2018). However, these areas are home to a variety of micro-habitats. Changes in soil chemical properties, available water resources, rainfall, and severe human intervention have led to diverse species in different parts of the plain (Dinarvand et al., 2018; Dinarvand et al., 2022a). Desert plants adapt to environmental conditions using different strategies. Micro-habitats and diversity of soil characteristics cause structural differences in vegetation composition in areas under the same climate (Tao et al., 2013). The Stability of an ecosystem depends upon the biodiversity parameters (Yadav and Mishra, 2013). In addition to being self-sustaining, diversity increases the resiliency of the plant community to disturbance (Quijas et al., 2010).

Plants play a pivotal role in the stability of natural ecosystems (Duran Zuazo and Rodnguez Pleguezuelo, 2008). As one of the basic concepts in natural resource management, diversity is essential to the health and production of ecosystems (Mesdaghi, 2005). While assessing the current state of vegetation, it is possible to provide appropriate management recommendations for the conservation and improvement of natural habitats by continuously measuring biodiversity during different periods (Dinarvand et al., 2016). Biodiversity experiments have generated robust empirical results supporting the hypothesis that ecosystems function better when they contain more species (Turnbull et al., 2016). High species richness affects the ecosystem's performance in four ways: 1) the improved species diversity (Loreau et al., 2001) and hence a better chance of survival from natural selection (Hector et al., 2010), 2) Prevention from unwanted environmental changes (Naeem et al., 2012). 3) Facilitation of the establishment of other plant communities (Bruno et al., 2003). In addition to affecting ecosystem performance, species diversity causes soil erosion by affecting root volume and dry matter. (Ford et al., 2016). Vegetation cover and diversity directly influence soil hydrology by creating a natural barrier, increasing infiltration, and improving evapotranspiration (Capilleri et al., 2016). The presence of an aerial cover along with the root system, rhizomes, and stolon physically prevents wind and water erosion (Gyssels et al., 2005). This study aimed to investigate the effect of tree cultivation on the richness and diversity of the local vegetation cover and identify and introduce the appropriate irrigation method for the restoration of the native vegetation cover from 2016 to 2019. The assessment of species diversity was done in 5 areas of dust hotspots in southwest Iran (Dinarvand et al., 2022a; Dinarvand et al., 2022b; Dinarvand et al., 2021a; Dinarvand et al., 2021b; Dinarvand et al., 2021c) This research was conducted in seven dust centers in southwestern Iran of Iran, to study the effect of tree plantations on native vegetation from 2019 to 2021.

Materials and methods

Study area

The Khuzestan province covers an area of 64236 km^2 in the southwest of Iran and the border with Iraq. It is situated in the latitudes 29°58′ to 32°04′ N of the Equator and longitudes 47°41′ to 50°49′ E of the Greenwich Meridian (Heidarian et al., 2018). In Khuzestan, there are large rivers, such as Karun, Karkhe, Dez, Zohreh, and Jarahi (Masoudi and Elhaeesahar, 2016). The elevation of the province ranges from 0 to 3500 m above sea level in Sefidkoh Mountain (Masoudi and Elhaeesahar, 2016). About 9% (349254 ha) of Khuzestan Plain is the source of dust (Heidarian et al., 2018; Azhdari et al., 2015). However, the subsequent comprehensive research showed that the area of 737790 ha of Khuzestan province is desert (Abbasi, 2021). A total of 39 native plant types have been identified in this area (Dinarvand et al., 2018). The main dust center of the southeast of Ahvaz is located 25 km away from Ahvaz city along the Ahvaz-Mahshahr highway between 48°47′ to 49°17′ E and 30°45′ to 31°15′ N. In this research, the diversity of species and the amount of production in seven cultivated hot spots of Bagan, Hofireh, Shoaimit Faleh, Shoamit Mandil, Sharifiieh, Seyed Sharaf, and Mosalemieh were investigated and compared with the control area (without tree-cultivation in 14 points) (figure 1).

Based on the modified De Martonne climatic classification method, Khuzestan province can be divided into three climatic classes: hot semi-arid, hot arid, and hot hyper-arid (Dinarvand and Jamzad, 2020). More than half of the area of the Khuzestan province, as well as the entire dust centers, is located in the hot hyper-arid climate category.

Climate data

Climate data from the Ahvaz synoptic station for the past 24 years (1996 – 2020) were obtained to prepare the ombrothermic diagram (figure 2). The average temperature of the study area was between 26.2 to 26.9 °C. The average maximum temperature ranges between 33 °C in the east to 33.4 °C and the west. The average minimum temperature falls between 19.2 °C in the west of the region and 19.5 °C in the east. Precipitation decreases from a maximum of 213 mm in the west to a minimum of 166 mm in the south. The area received ample rainfall in the fall of 2018 and spring of 2019, leading to seasonal floods.

According to the Global Bioclimatic Classification System of Rivas Martinez, Khuzestan province has "Tropical desert and "Tropical xeric" in the south and "Mediterranean desert continental" in the north (Djamali et al., 2012).

Floristic survey

Plant specimens were identified at species, subspecies, and variety using relevant Floras, mainly "Flora of Khuzestan Province" (Dinarvand, 2021), "Flora Iranica" (Rechinger, 1963-2015), "Flora of Iran" (Assadi et al., 1988–2018),

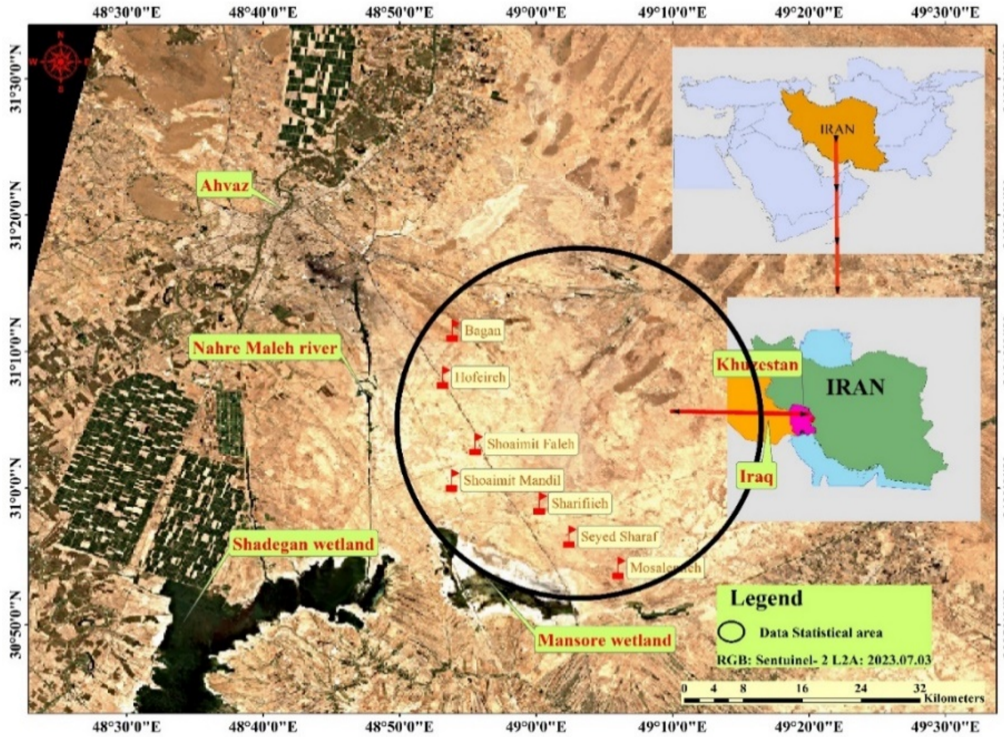

Figure 1. Map of the location of the selected points of statistics areas.

"Flora of Khuzestan" (Mozaffarian, 1999), "Flora of Iraq" (Townsend and Guest, 1974-1985), "Flora Palestina" (Zohary, 1966-1986) and "Trees and Shrubs of Iran" (Mozaffarian, 2005).

Plant sampling method

To dust control, 26,000 ha of the dusty center of southwestern Iran were stabilized by planting *Prosopis juliflora* in Khuzestan province, Iran from 2015 to 2021. This study was conducted to investigate the effect of tree planting on the richness and diversity of the local plant species and identify the appropriate irrigation methods for tree plantations and increasing the native vegetation cover. In this research, the richness and diversity of plant species and the amount of vegetation production were investigated. During the field survey, a total of 420 fixed plots were established for both tree planting and control sites (without tree planting) in seven areas of Bagan, Hofireh, Shoaimit Faleh, Shoamit Mandil, Sharifiieh, Seyed Sharaf, and Mosalemieh in Ahvaz County, Iran. The minimum plot size was determined based on species-area curves produced for each unit sampled (Kent, 2012; Asri, 1995). The Braun Blanquet method was used in estimating the canopy cover percentage of each species on plots (Maarel, 2005). The specifications of the plots were recorded for the following seasons with a GPS device. The amount of fodder production in 5 plots inside the cultivated area and 5 plots outside the cultivated area was taken from the collar surface with scissors and weighed

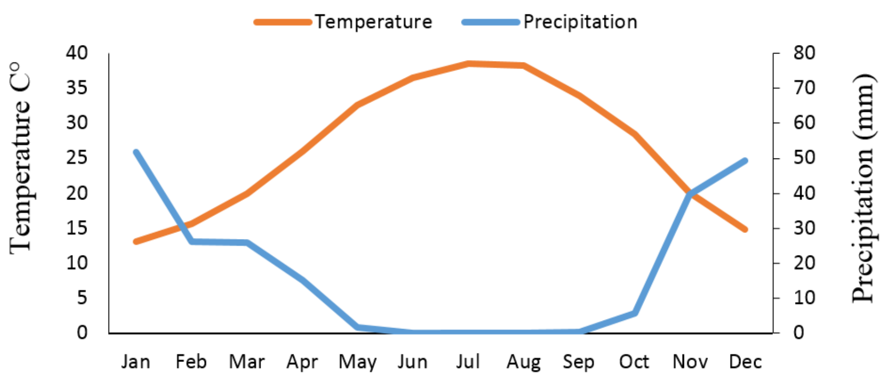

Figure 2. Ombrothermic diagram of Ahvaz City for the past 24 years (1996 – 2020).

in the laboratory environment after drying.

Data analysis

Dominance, Evenness, and diversity indices (Simpson and Shannon diversity indices) were measured using the PAST 4.09 software by considering vegetation cover percentage. Simpson and Shannon-Wiener indices were used to determine species diversity given their complementary nature. The Shannon-Wiener index is more affected by species richness, while the Simpson index is more sensitive to the abundance of the dominant species (Ejtehadi et al., 2008). The Kolmogorov-Smirnov test was employed to evaluate the normality of vegetation cover data and the Levene test to measure the equality of variances. Data analysis (ANOVA) between regions was performed using the SPSS software 16 version. T-test analysis was used to compare the mean of fodder production and diversity indices in cultivated areas and control areas.

Results

Floristic composition

A total number of 57 species and infraspecific taxa of vascular plants belonging to 18 plant families have been collected and identified from the study area. The percentage of vegetation cover of each of the native species in the plots was measured in the field survey. In some areas, only one species was dominant and in the other areas, more than one species was dominant. In all regions, the dominant species were halophytes, from two families Amaranthaceae and Poaceae. The percentage of vegetation cover of dominant species extracted from fixed plots is mentioned in Table 1.

Species diversity

In Hofeireh, Sharifiieh, Shoaimit Mandil, and Seyed Sharaf region Simpson and Evenness indices were higher than Dominance, and in Mosalemieh region, the indices were equal. In the Bagan and Shoaimit Faleh region, the Dominance index was higher than the Simpson and Evenness indices (Table 2).

The results of the T-test analysis showed that the average indices of vegetation diversity under investigation including Taxa_S, Individuals, Dominance_D, Simpson_1-D, Shannon_H, and Evenness_e^H/S for Seyed Sharaf, Shoaimit Mandil, Sharifiieh, Bagan, Shoaimit Faleh and Hofeireh regions was significant, but in Mosalemieh region, only Taxa_S and indicators were significant and other indicators were not significant (Table 3).

In the seven studied areas except the Mosalemieh, the percentage of coverage in the areas under tree cultivation was higher than the control areas (figure 3).

There was a significant difference between tree planting and control areas for fodder production. The amounts of fodder production in the plantation area were always higher than that for control areas (figure 4).

Table 1. Average coverage percentage of dominant plant species in the studied areas (collected from the sampling plots, 2021).

Region	Fam	Species	Cover %
Shoamit Faleh	*Amaranthaceae*	*Salsola jordanicola*	51.0
Hofeireh	*Amaranthaceae*	*Atriplex leucoclada*	11.7
Bagan	*Amaranthaceae*	*Seidlitzia rosmarinus*	52.7
Sharifiieh	*Amaranthaceae*	*Salsola jordanicola*	30.7
Sharifiieh	*Amaranthaceae*	*Aeloropus lagopoides*	27.2
Sharifiieh	*Amaranthaceae*	*Bienertia cycloptera*	12.8
Shoaimit Mandil	*Poaceae*	*Aeloropus lagopoides*	21.1
Shoaimit Mandil	*Amaranthaceae*	*Salsola jordanicola*	17.8
Seyed Sharaf	*Poaceae*	*Aeloropus lagopoides*	25.1
Seyed Sharaf	*Amaranthaceae*	*Atriplex leucoclada*	24.6
Seyed Sharaf	*Amaranthaceae*	*Salsola jordanicola*	11.7
Seyed Sharaf	*Amaranthaceae*	*Bienertia cycloptera*	11.1
Mosalemieh	*Poaceae*	*Aeloropus lagopoides*	33.5
Mosalemieh	*Amaranthaceae*	*Salsola jordanicola*	16.5

Table 2. Diversity indices in the study areas sites in seven study areas.

	Shoaimit Faleh	Hofeireh	Bagan	Sharifiieh	Shoaimit Mandil	Seyed Sharaf	Mosalemieh
Dominance_D	0.6	0.3	0.6	0.4	0.4	0.4	0.5
Simpson_1-D	0.3	0.7	0.4	0.6	0.5	0.6	0.5
Evenness_e^H/S	0.4	0.7	0.5	0.5	0.6	0.6	0.5

Table 3. T-test analysis results of diversity indices in the study areas.

Region	Indices	Mean	Std. Deviation	SEM	df	P value
Mosalemieh	Taxa_S	5.13	1.00	0.18	29	**
	Individuals	55.24	22.02	4.02	29	ns
	Dominance_D	0.53	0.13	0.02	29	ns
	Simpson_1-D	0.47	0.13	0.02	29	ns
	Shannon_H	0.86	0.20	0.03	29	ns
	Evenness_e^H/S	0.50	0.11	0.02	29	**
Seyed Sharaf	Taxa_S	5.30	0.91	0.16	29	**
	Individuals	78.25	20.17	3.68	29	**
	Dominance_D	0.43	0.14	0.02	29	**
	Simpson_1-D	0.57	0.14	0.02	29	**
	Shannon_H	0.93	0.13	0.02	29	**
	Evenness_e^H/S	0.59	0.12	0.02	29	**
Shoaimit Mandil	Taxa_S	4.80	1.06	0.16	29	**
	Individuals	47.52	28.62	5.22	29	**
	Dominance_D	0.45	0.12	0.02	29	**
	Simpson_1-D	0.55	0.12	0.02	29	**
	Shannon_H	0.91	0.11	0.02	29	**
	Evenness_e^H/S	0.62	0.14	0.02	29	**
Sharifiieh	Taxa_S	3.30	1.34	0.24	29	**
	Individuals	78.37	17.46	3.18	29	**
	Dominance_D	0.38	0.08	0.01	29	**
	Simpson_1-D	0.62	0.08	0.01	29	**
	Shannon_H	0.98	0.06	0.02	29	**
	Evenness_e^H/S	0.53	0.11	0.02	29	**
Bagan	Taxa_S	4.20	1.27	0.233	29	**
	Individuals	74.29	17.02	3.01	29	**
	Dominance_D	0.62	0.21	0.03	29	**
	Simpson_1-D	0.38	0.21	0.02	29	**
	Shannon_H	0.66	0.30	0.05	29	**
	Evenness_e^H/S	0.52	0.13	0.02	29	**
Shoaimit Faleh	Taxa_S	5.53	1.71	0.13	29	**
	Individuals	65.96	20.08	3.66	29	**
	Dominance_D	0.66	0.15	0.02	29	**
	Simpson_1-D	0.34	0.15	0.02	29	**
	Shannon_H	0.68	0.23	0.04	29	**
	Evenness_e^H/S	0.40	0.12	0.02	29	**
Hofeireh	Taxa_S	5.97	0.99	0.18	29	**
	Individuals	35.13	17.86	3.26	29	**
	Dominance_D	0.31	0.05	0.01	29	**
	Simpson_1-D	0.69	0.05	0.01	29	**
	Shannon_H	1.00	0.01	0.01	29	**
	Evenness_e^H/S	0.69	0.10	0.01	29	**

**, ns = significant in 1% probability level and no significant, respectively.
SD = Standard Deviation, SEM = Standard Error of Mean

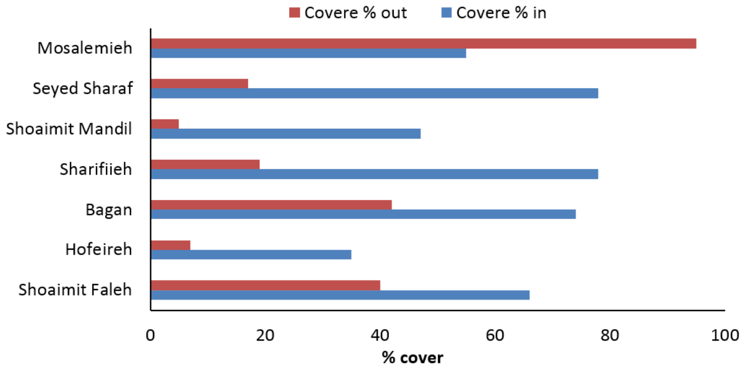

Figure 3. Means of the percentage of vegetation cover in tree planting and control sites in seven study areas.
Means of columns followed by same uppercase and lowercase letters indicating no significant differences between tree planting and control sites, respectively.

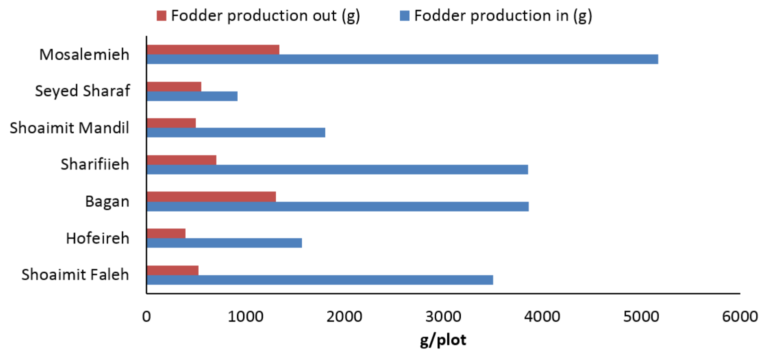

Figure 4. Means of fodder production (biomass) in the tree planting and control sites in seven study areas.
Means followed by similar uppercase and lowercase letters indicate no significant differences between tree planting and control sites, respectively.

Discussion

The native species have a great role in the region because the vegetation can increase the entrapment of mobile sand and dust, and decrease soil loss by the wind as a result of the reduction of soil erodibility and wind speed (Al-Dousari et al., 2020; Meng et al., 2018). A total of 155 plant species belonging to 35 families had been identified in the dryland region of southwest Iran (Dinarvand and Jamzad, 2020). In the study area, 57 species and infraspecific taxa of vascular plants belonging to 18 plant families have been collected and identified. In some regions, only one species was dominant; in others, more than one species was dominant. In all sites, the dominant halophyte species were from two families of *Amaranthaceae* and *Poaceae*. *Seidlitzia rosmarinus*, *Atriplex leucoclada*, *Salsola jordanicola*, *Bienertia cycloptera*, and *Aeloropus lagopoides* were the dominant plant species (with coverage percentages ranging from 11 to 53%) in the selected areas (Table 1). These plants were often woody or had a fleshy body and were suitable for salinity and little rainfall areas. On the other hand, due to the production of abundant winged seeds or creeping stems, they are well established and furnish the area if there is minimal water.

Diversity depends on the plant species richness, abundance, and evenness, so drylands are sometimes more diverse than productive areas (Kier et al., 2005; Field et al., 1998). The results of the analysis of the diversity indices obtained from the study of the coverage percentage measured from the sampling plots and richness showed that significant differences were observed in the study areas.

In the Shoaimit Mandil, there were no furrows, and irrigation was done by tanker truck; in this site, the *Salsola jordanicola* was the only dominant species with 51%. The diversity indices showed that the Dominance index was higher than other sites, and so, the other diversity indices Simpson, Shannon, and Evenness indices were decreased. It is important to mention that the presence of furrows next to cultivated shrubs causes better accumulation of rainwater and absorption of water by cultivated trees.

In the Hofeireh site, the irrigation of furrows was done by tanker trucks. The dominant plant species was *Atriplex leucoclada* with a value of 11%, but due to the uniform distribution of this species along with other species in this site, the diversity and Evenness indices had increased.

In Bagan, the dominant species was *Seidlitzia rosmarinus* (52.7%). There was no furrow in this site and irrigation of cultivated plants was done by tanker trucks. The Dominance index was superior to Shannon, Simpson, and Evenness diversity indices.

In the Sharifiieh, *Salsola jordanicola* (30.7%), *Aeloropus lagopoides* (27.2%) and *Bienertia cycloptera* (12.8%) were the dominant species. In this site, the irrigation of cultivated trees was done by tanker trucks. The uniform distribution of species was due to decreases in Dominance index and increases of diversity indices in the site area.

In Shoaimit Mandil, the dominant species were *Aeloropus lagopoides* (21.1%) and *Salsola jordanicola* (17.8%). In this region, the water channels were close to the region, so, the irrigation was done by running water. According to the data taken from the vegetation coverage and richness, the dominance index was lower than the diversity indices.

In the Seyed Sharaf region, irrigation of cultivated trees was done by tanker trucks. Its dominant species were *Aeloropus lagopoides* (25.1%), *Atriplex leucoclada* (24.6%), *Salsola jordanicola* (11.7%) and *Bienertia cycloptera* (11.1%). In this site, the diversity indices were higher than the Dominance index.

In the Mosalemieh, the species *Aeloropus lagopoides* (33.5%) and *Salsola jordanicola* (16.5%) were the dominant. In this region, irrigation of cultivated plants was done by tanker trucks and the numerical value of the dominance and diversity index was the similar in this site (figure 3).

The diversity indices for all sites were also compared with the neighboring control area. The results of the T-test analysis of Simpson's and Shannon's diversity indices, richness, coverage percentage, and evenness in the selected areas showed that except for the Mosalemieh region, a significant difference between the cultivated shrubs and the control areas is observed (Table 2, Table 3).

Due to its proximity to the Shadgan wetland and the influence of its hydrological flows, the Mosalemieh site had different conditions compared to other locations. Field observations and measurements of fodder production (biomass) in the tree planting and control areas showed that in the tree planting areas, the amount of fodder production was higher than that for the control (figure 4). The results of previous studies of evaluation of changes in native vegetation cover of dust sources in the cultivated regions with different irrigation systems were done by Dinarvand et al. (2022a). Their results showed that in the selected areas, various irrigation methods along with rainfall caused significant positive changes in vegetation cover, the number of species, and increasing diversity from 2018 to 2020. Their results indicated a significant difference between the average dominance index, Simpson and Shannon indices, and vegetation cover, as well as the number of species in different years. Jafarian and Mirjalili (2017) in a study in the Bolbol rangeland of Yazd concluded that increases in vegetation cover were possible using rain harvesting such as the development of pitting and contour furrows. So, the results revealed that irrigation of cultivated shrubs and the creation of a suitable substrate for rainwater storage cause significant changes in species diversity and the return of native species.

Conclusion

The results of monitoring the vegetation changes of the dust center of southwest Iran, during the periods investigated in this research showed that irrigation coupled with rainfall has an effective role in the species diversity of the local vegetation in the deserts and the restoration of fragile pastures. From the above observations and results, it could be concluded that the region has a suitable native seed bank, and if the growth condition is provided for these reserves and water is available, the native vegetation will be established. But it should not be forgotten that despite the return of several plant species after the irrigation of cultivated seedlings, the studied area is still very sensitive and fragile and needs to be managed and irrigated until proper restoration.

Authors Contributions
All authors have contributed equally to prepare the paper.

Availability of Data and Materials
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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