ISSN: 2538-2152; ECOPERSIA 2022;10(1):1-11.

Effects of semi-circular bunds on plant vegetation and soil properties of Naroon and Neron rangelands- Sistan and Baluchestan

ARTICLEINFO

Article Type
Original Research

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How to cite this article
Ebrahimi E. Effects of semi-circular bunds on plant vegetation and soil properties of Naroon and Neron rangelands- Sistan and Baluchestan. ECOPERSIA 2022;10(1): 1-11

DOR:
20.1001.1.23222700.2022.10.1.2.5

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Article History
Received: August 27, 2020
Accepted: June 2, 2021
Published: December 23, 2021

ABSTRACT

Aim: In this paper, the semi-circular bund treatments were contrasted with addressing the following questions: how does semi-circular bund affect the vascular plants' richness and diversity in Naroon and Neron rangelands of Sistan and Baluchestan? and make the soil properties responses to the semi-circular bund?

Materials & Methods: Next to every site, a site was selected as controlled ones. Vegetation (production, vegetation cover, density, richness, diversity) and soil data (texture, pH, EC, organic carbon, total nitrogen, available phosphorus, available potassium, $CaCO_3$) were analyzed in a completely randomized design.

Findings: In total, 11 species from 6 families and 8 genera were observed. Control treatment of Neron exhibited the highest number of plant species. Semi-circular bunds had the highest vegetation cover, production, and density. The highest and lowest species richness and diversity were measured in Naroon and Neron semi-circular bunds. Results showed that the amounts of organic carbon, nitrogen, potassium, and phosphorus increased significantly in semi-circular bunds than in the control areas—the highest organic carbon, nitrogen, and potassium related to Neron semi-circular bund. Naroon and Neron semi-circular bunds had the highest amounts of clay, and the most negligible value was measured in the control treatments.

Conclusion: In total, the results of the study showed that semi-circular bund had a positive effect on vegetation cover and soil properties in the rangelands of the study area.

Keywords: Species richness, Rangeland reclamation, Soil physical and chemical properties.

CITATION LINKS

[1] Al-Rowaily SL, El-Bana MI, Al-Bakre DA, Assaeed AM, Hegazy AK, Ali MB. Effects of ... [2] Faraji F, Alijanpour A. Sheidai Karkaj E, Motamedi J. Effect of ... [3] Khosravi H, Ebrahimi M, Rigi M. Effects of rangeland... [4] McSherry ME, Ritchie ME. Effects of... [5] Ebrahim M, Mohammadi F, Fakhireh A, Bameri A. Effect of... [6] Jafari M, Ebrahimi M, Azarnivand H, Madahi A. The effects of ... [7] Arab M. Effect of the improvement operations on ecological ... [8] Ebrahimi M, Khosravi H, Rigi M. Short-term grazing exclusion ... [9] Khosravi H. Effect of improvement operations on reclamation of... [10] Delavari A, Bashari H, Tarkesh M, Mirkazehi A, Mosadeghi MR. Evaluating... [11] Ata Rezaei A, Arzani H, Tongway D. Assessing rangeland capability in... [12] Report of Rangeland Improvement, Koteh, Sistan, and Baluchestan... [13] Cain SA. The Species-Area Curve. Am [14] Hanley TA. A comparison of the line-interception and quadrat ... [15] Coulloudon B, Eshelman K, Gianola J, Habich N, Hughes L, Johnson C, Pellant M, Podborny P, Rasmussen A, Robles B, Shaver P, Spehar J, Willoughby J. Sampling ... [16] Heath ME, Barnes RF, Metcalfe DS. Forages: The science of ... [17] Baghestani N, Arzani H, Zare T. Abdollahi J. Study... [18] Arzani H, Zohdi M, Fish E, Zahedi A, Nikkhah GHA, Wester D. Phenological... [19] Bagheri H, Adnani M, Tavili A. Studying... [20] Zhang TH, Su YZ, Cui JY, Zhang ZH, Chang XX. A leguminous ... [21] Jiang G, Xingguo H, Jianguo W. Restoration and [22] Wang A, Luo C, Yang R, Chen Y, Shen Z, Li X. Metal leaching along soil profiles after the EDDS application–A field... [23] Thomas GW. Soil pH and soil... [24] Rhoades JD.... [25] Bremner JM. Nitrogen total. In: Bartels JM... [26] Allison LE, Moodie CD, Carbonates. In: Black CA (ed.). Methods of Soil Analysis, American Society of... [27] Lo I, Tsang D, Yip T, Wang F, Zhang WH. Influence of injection conditions on EDDS-flushing of... [28] Bray RH, Kurtz LT. Determination of total, organic and... [29] Knudsen D, Peterson GA, Pratt P. Lithium, sodium and... [30] Suganuma MS, de Assis GB, Durigan G. Changes in plant... [31] Rodrigues RR, Lima RAF, Gandolfi S, Nave AG. On... [32] Zhou G, Wei Q, Li B, Zeng X, Liu G. Establishment and... [33] Jafarian A, Jafari M, Tavili M. Assessment of Haloxylon... [34] El-Keblawy A, Ksiksi T. Artificial forests as... [35] Stinca A, Battista Chirico G, Incerti G, Bonanomi G. Regime shift by... [36] Rokhfirooz G, Ghorbani J, Shokri M, Jafarian Jelodar Z. Effect of ... [37] Yari R, Tavili A, Zare S. Investigation on... [38] JavidfarA, Rouhi-Moghaddam E, Ebrahimi M. Some... [39] Barker DJ, Dodd MB, Wedderburn M.E. Plant... [40] Jobbágy EG, Osvaldo ES. Controls of grass... [41] Aguilera E, Gutiérrez JR, Meserve PL. Variation in... [42] Rathore VS, Singh JP, Bhardwaj S, Nathawat NS, Mahesh... [43] Hashemi Rad M, Ebrahimi M, Shirmohammadi E. Land... [44] Li X, He MZ, Jia RL. The response of desert plant... [45] GonzalesE K, Clements D R. Plant community...

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Introduction

Natural resources are the life bed of ecological systems. Performing appropriate methods for protecting and restoring these ecological systems can provide the basis for their sustainable operation. For the proper management of natural resources, recognizing appropriate methods are essential. Degraded rangelands require restoring operations to achieve optimal condition [1] since severe degradation of natural areas has led to increased soil erosion and reduced land potential. Due to the increasing population and increasing need for food, soil protection and maintenance of potential and restorable lands in watersheds is necessary [2].

In this way, one of the most seriously degraded natural ecosystems in Iran is the arid mountainous region of Taftan, which is located in Sistan and Baluchestan province. Soil erosion is one of the most severe environmental problems in the Taftan region, which critically threatens the sustainability of natural resources. It has led to decrease biodiversity, vegetation cover, and soil fertility. It has also increased species loss and the substitution of endemic species by exotic species [3]. It is interesting to note that the main problem of natural areas in Iran is finding the most appropriate method to prevent erosion, runoff, sedimentation, and increasing storage of precipitation in the soil, especially on lower slopes, to restore the rangelands [4,5]. In this way, the semi-circular bund is one of the effective practices used in arid lands [6,7,8]. It aims to increase soil and vegetation enrichment in rangelands [6,7]. However, some studies have evaluated such restoration practices in the rangelands of Iran, the effects of the semi-circular bund on the function of rangeland ecosystems have not been apparent. In some areas, it had positive effects on the restoration of plant cover and soil properties [9, 10], while in some areas, it showed adverse effects on the reclamation of plant communities and soil properties [6, 7].

Rangelands evaluation in reaction to restoration practices is essential for rangeland managers, mainly when the output directly influences management decision–making [11]. It might be trying to search for proof of landscape degradation or restoration, and the procedure needs to have equal facility in dealing with these scenarios. In addition, it may help to guide sustainable management techniques for conserving natural ecosystems [1].

This study was conducted to determine the influence of semi-circular bund on the vegetation cover and soil properties of the vegetation communities in Naroon and Neron rangelands in the Taftan area with restrictive soil and climate conditions to determine whether the ecosystems have been restored comparison with the control treatments (without semi–circular bund). In this paper, our objectives were [1] to describe the plants' richness and diversity of arid mountainous rangelands under semi-circular bund treatment in southeastern Iran and [2] to study the impacts semi-circular bund on the soil properties.

Materials & Methods

Study description

The study area is situated in Khash city, Sistan and Baluchestan province, Iran, between latitude28 ° 23′ 41′′–28° 39′ 00′′ N and between longitude 60° 47′ 04′′–28° 23′ 09′′E) (Figure 1). The regional climate is classified as cold arid (Köppen), with annual mean precipitation of 160 mm, and mean temperature of 19.7°C. The minimum and maximum elevations are 1400 m in the south to 3000 m north of sea surface level. The area represents a typical arid mountainous landscape, covered by a mosaic of bush-forb and bush-tree (Figure 2). In this study, two rangelands under semi-circular bund treatment operations, including Naroon rangeland with an average height of 1671 m and Neron rangeland with an average height of 2680 m, were selected study the semi-circular bund effects on vegetation and soil restoration. The areas were undergoing semi-circular bund projects for 10 years [12].

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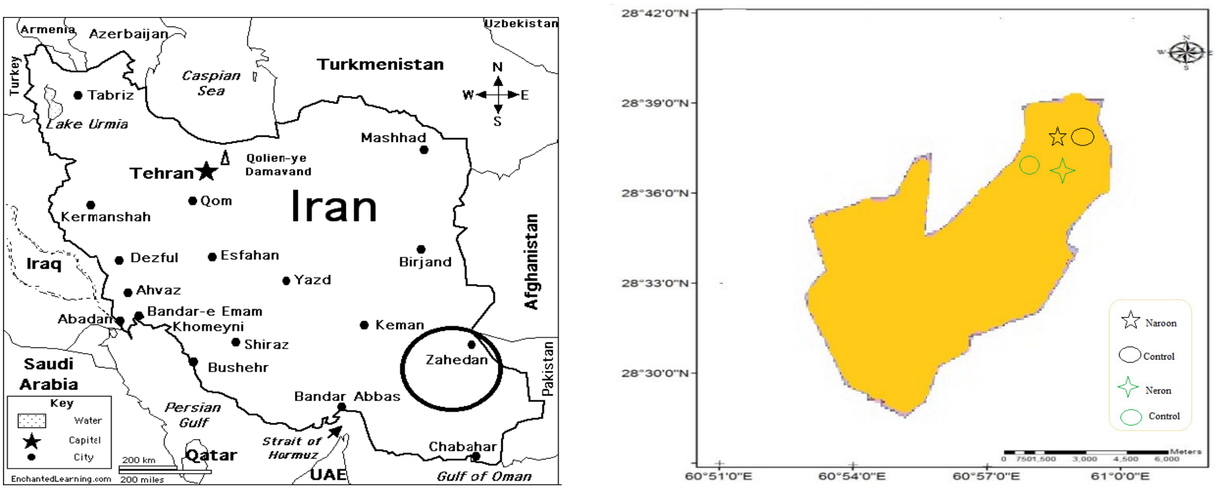

Figure 1) Location of the study area in Sistan and Baluchestan Province, Iran.

Figure 2) Semi–circular bund area (a) and control area (b).

Sampling method

First, by preparing basic maps, the studied general area was determined. In each area, the length of transects was determined to be 50 m based on the vegetation changes and size of the study area. Alongside each transect, 2 plots of 8 m^2 were systematically placed at intervals of 10 and 40 m. Plot size was determined based on vegetation type and distribution using the minimal area method [13]. A total of 12 transects and 24 plots was considered in all sampling areas. For each sampling area, a site without semi–circular bund was taken as a control. Except in two semi-circular bund and grazing livestock factors, there was no significant difference between spatial heterogeneity (topography, soil type, distribution of traits, event, or relationship across the area) among the selected sites. Data were collected during the growing season (May).

Data on the plant cover was obtained using the quadrat estimation methods [14]. The plant production was estimated using the clipping and weighing method [15]. The plant density was measured by counting the number of species in a plot [15]. Plant species were classified as class I (High), II (Medium), and III (Low) according to their palatability. Palatability shows which part of a plant is consumed by grazing animals [16]. In the present study, palatability was determined using reference texts [17,18, 19]. The importance value (IV) for the plant species was measured using the following formula [20]:

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$$IV = \frac{RD + RC + RF}{3} \quad \text{Eq. (1)}$$

where *RD* is the relative density (the ratio of the number of individuals of a species to the total number of individuals of all species, %); RC is the relative cover (the ratio of the cover of a species to the total cover of all species, %); and RF is the relative frequency (the ratio of the percentage frequency of a species to the total frequency of all species, %) [21].

Shannon species diversity index [H'=−Σ pi. lnpi] [20] was determined by calculating the frequency of each plant species (pi = proportion of points along each transect at which species i was recorded). Plant species richness (S= number of species sampled per transect) and evenness of species abundances (Pielou's J index = H'/lnS) were also calculated for each transect.

Soil samples were taken at three points along the transects in each site (within quadrates at three points) using a soil auger from the surface layers (0–30 cm). The soil samples in each quadrat were then mixed to make one composite sample. A total of 36 soil samples were selected (9 soil samples at each site). The soil samples were put in plastic bags and labeled; they were that air-dried and taken to the laboratory to analyze soil physical and chemical properties. The soil texture was determined using laser diffractometry [22]; the soil pH was determined in a 1:5 soil to distilled water slurry after one hour of agitation using a digital pH–meter [23]; electrical conductivity of saturated soil paste extract (ECE) using an EC–meter [24]; total soil N (N_{ot}) was analyzed calorimetrically with a continuous flow ion analyzer following wet digestion in sulfuric acid [25]; Calcium carbonate ($CaCO_3$) was determined volumetrically by a calcimeter [26]. Organic carbon content (OC) was determined using the methods described by Lo *et al*. [27]. Available phosphorus (P) was measured by the method of Bray and Kurtz [28]. Available potassium (K) was assessed by the flame photometry method [29].

Data Analysis

The statistical processing was mainly conducted by one-way analysis of variance (ANOVA) and T-test. Before performing analysis, data were checked for their normality with the Kolmogorov–Smirnov test and homogeneity of variance with the Levene test ($p<0.05\%$), and where necessary, data were log-transformed. The soil and plant properties between the semi-circular bund sites and control sites were compared by T-test. The statistical significance of the differences between treatments was evaluated by analysis of variance (ANOVA). Duncan t-test between means was calculated if F-test was significant at the 0.05 level of probability. A probability of 0.05 or lower was considered significant. All statistical calculations were performed using SPSS release 18.0.

Findings and Discussion

The effect on the composition of plant species

A list of plant species was identified and prepared to identify the plant species in the studied areas. Based on Tables 1 and 2, 11 plant species were listed in the study areas, which belonged to 6 families and 8 genera. The highest number of plant species belonged to Naroon semi-circular bund site. The highest frequency belonged to the families of Compositae (41%), Papilionaceae (26%), and Chenopodiaceae (19%), respectively. The semi-circular bund sites showed the highest numbers of plant species, of which 90% were perennials with higher importance value. The importance value showed that three plant species were dominant in the semi-circular bund sites: *Salsola tomentosa*, *Artemisia santolina*, and *Zygophyllum eurypterum*. The plant species of *Z. eurypterum*, *Ar. sieberi* and *Ar. lehmanniana* were more abundant, with higher importance values in the control sites than in the semi-circular bund areas (Table 1). The construction of semi-circular bund in both study areas increased the richness of perennial species, which provides an opportunity for the establishment and growth of other plant species under the canopy of perennial plants [7]. Positive ecological changes in plant communities

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Table 1) The composition of plant species at semi-circular bund areas.

Species	Family	Palatability class	Growth form	Life history	Naroon Presenc/ Absence	Naroon IV (%)	Naroon Frequency (%)	Neron Presence/ Absence	Neron IV (%)	Neron Frequency (%)
Zygophyllum eurypterum	Zygophyllaceae	II	Sh	P	1	21.12	42.30	0	0	0
Hammada salicornia	Chenopodiaceae	I	Sh	P	1	14.32	25.14	0	0	0
Artemisia santolina	Compositae	II	B	P	1	26.42	100	0	0	0
Salsola tomentosa	Chenopodiaceae	I	F	P	1	36.24	100	0	0	0
Artemisia lehmanniana	Compositae	I	B	P	0	0	0	1	13.28	12.51
Artemisia sieberi	Compositae	II	B	P	0	0	0	0	0	0
Amygdalus lycioides	Rosaceae	II	Sh	P	0	0	0	0	0	0
Astragalus semnanica	Papilionaceae	III	F	A	0	0	0	1	14.26	13.92
Amygdalus scoparia	Papilionaceae	II	Sh	P	0	0	0	0	0	0
Alhaji camelorum	Papilionaceae	III	F	P	0	0	0	0	0	0
Euphorbia helioscopia	Euphorbiaceae	III	F	A	0	0	0	1	13.43	12.15

Sh: Shrub, F: Forb, B: Bush, P: Perennial, A: Annual
IV: importance value
1: Presence of species, 0: Absence of species

Table 2) The composition of plant species at control areas.

Species	Family	Palatability class	Growth form	Life history	Naroon Presenc/ Absence	Naroon IV (%)	Naroon Frequency (%)	Neron Presence/ Absence	Neron IV (%)	Neron Frequency (%)
Zygophyllum eurypterum	Zygophyllaceae	II	Sh	P	1	36.72	100	0	0	0
Hammada salicorni	Chenopodiaceae	I	Sh	P	1	13.42	45	0	0	0
Artemisia santolina	Compositae	II	B	P	1	24.53	100	0	0	0
Salsola tomentosa	Chenopodiaceae	I	B	P	0	0	0	0	0	0
Artemisia lehmanniana	Compositae	II	B	P	0	0	0	1	25.19	100
Artemisia sieberi	Compositae	II	B	P	0	0	0	1	29.43	100
Amygdalus lycioides	Rosaceae	II	Sh	P	0	0	0	1	19.20	45.19
Astragalus semnanica	Papilionaceae	III	F	A	0	0	0	1	17.62	41.27
Amygdalus scoparia	Papilionaceae	II	Sh	P	1	16.31	38.14	0	0	0
Alhaji camelorum	Papilionaceae	III	F	P	0	0	0	1	9.21	19.26
Euphorbia helioscopia	Euphorbiaceae	III	G	A	0	0	0	0	0	0

Sh: Shrub, F: Forb, B: Bush, P: Perennial, A: Annual
IV: importance value
1: Presence of species, 0: Absence of species

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Table 3) Comparison of plant properties in the study area.

Area	Density (n m^{-2}) I	II	III	Canopy cover (%)	Production (Kg ha^{-1})	Diversity (H′)	Richness	Evenness
Naroon	-	-	0.68±0.03^{Aa}	15.87±3.50^{Ab}	19.04±2.43^{Ab}	0.58±01^{Aa}	1.24±0.09^{Aa}	1.00±0.10^{Aa}
Control	-	120900.0±^{c}	0.12±0.01^{Bc}	7.70±1.27^{Bc}	9.24±0.88^{Bc}	0.48±0.03^{Aab}	0.96±0.23^{Bb}	1.00±0.10^{Aa}
Neron	-	12.900.10±^{Aa}	0.06±0.07^{Bc}	28.83±0.15^{Aa}	34.60±0.18^{Aa}	0.33±0.08^{Ab}	0.33±0.27^{Ac}	1.19±0.10^{Aa}
Control	-	6.980.00±^{Bb}	0.27±0.12^{Ab}	13.60±1.41^{Bb}	16.32±1.69^{Bb}	0.23±0.10^{Ac}	0.55±0.31^{Abc}	1.07±0.10^{Aa}

* Values shown are the means± SE. Different capital case letters in each column indicate significant differences with controls (p‹0.05, t-Test). Different lower letters in each column indicate significant differences among treatments (p‹0.05, post hoc Duncan test).

increase the ecological niches of plant species and thus provide an environment for trapping the seeds of other plants and subsequently creating plant masses [30]. Richness and diversity are essential features of the ecosystem that should be considered during vegetation recovery [31]. A semi-circular bund with increasing ecotone density and landscape diversity can be helpful for landscape composition [7]. Therefore, plant establishment resulting from increasing soil moisture causes micro-habitat for the growth of other plant species in arid areas [32]. The habitat–modifying capacity of a plant can alter its environment, both above and below–ground. The microclimate creates a decrease in air temperature, followed by a decrease in evapotranspiration. Jafarian et al. [33] indicated the changes and improvements in vegetation composition due to rangeland improvement operations by improving soil characteristics.

Plant establishment during rangeland reclamation may cause an accumulation of mineral nutrients and water, leading to a local increase in soil fertility [34], and may protect the understory species against high irradiance and temperature [35]. Favorable soil and micro–climatic conditions underneath plant canopies act as “nutrients resource” for understory herbaceous plants [36]. These resources are essential to arid land rehabilitation because they may spur natural succession by facilitating the growth of other plants [3]. They investigated the effect of rangeland improvement and restoration operations on the composition and diversity of seed reserves of soil species in the rangelands of Kabir Savadkooh Watershed of Mazandaran Province. Rokhfirooz et al. (37) also concluded that soil seed banks could be changed due to restoration operations, and this change depends on the level of changes in vegetation due to restoration operations, type of operation, and duration of the project.

The effects on vegetation characteristics

Results of comparing the percentage of cover and vegetation production of the semi-circular bund sites with the control areas (t-test) revealed that the semi-circular bund sites were significantly different from the control areas in terms of vegetation cover (Table 3) and the percentage of cover in semi-circular bund sites was more than that of control areas (p<5%). A similar increment was obtained in the plant production following semi-circular bund operation.

All semi-circular bund sites showed a significant increase in vegetation production (p<5%). Considering the habitat conditions and flora of the area, plants of class I was rarely present in the composition, so that crescent semi-circular bund rangelands and control rangelands did not have plants of class I, and such species were not added to the flora of the rangeland as a result of semi-circular bund operations. Comparison of plant densities of class II in semi-circular bund sites with the control areas (Table 3) showed that class II species in the Neron semi-circular bund sites were significantly different from those of control areas (p<5%),

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but class II species were not observed in the Naroon semi-circular bund sites. The density of class III species showed that class III species were higher in semi-circular bund sites than in the control areas (Table 3).

Comparing density of plant species of class III showed that class III species in the semi-circular bund areas were more than those of the control areas (Table 3). Comparing the species richness index of semi-circular bund areas with the control sites (t-test) showed that species richness in semi-circular bund areas was higher than that of the control areas, but only Neron semi-circular bund was significantly different from the control sites ($p<5\%$). The plant species diversity and evenness of the semi-circular bund areas were not significantly different from the control sites (Table 3).

Results of analyzing the variance of vegetation characteristics of all areas showed that the plant production of all areas was significantly different ($p<5\%$). The highest plant production belonged to Neron semi-circular bund (34.60 kg ha^{-1}), and the lowest plant production belonged to Neron control (9.24 kg ha^{-1}). Such a result was obtained by comparing the vegetation cover. There was a significant difference in the vegetation cover ($p<5\%$) and density ($p<1\%$) of studied plant species. The highest density of class III species belonged to Neron semi-circular bund, and the lowest density of plant species was measured at Neron semi-circular bund. Results of analysis of variance of species diversity and richness indices (Table 3) revealed that species richness and diversity indices were significantly different ($p<5\%$). The highest values of Shannon and Menhinick indices were measured at Naroon semi-circular bund area. The lowest values of Shannon and Menhinick indices belonged to Neron semi-circular bund and its control area, respectively. Results indicated no significant difference for the evenness index of studied areas (Table 3).

Due to creating favorable soil humidity conditions, a semi-circular bund creates a better structure for vegetation cover. Therefore, due to seasonal rainfall, the most important goals of the semi-circular bund construction in the rangeland, including strengthening vegetation, increasing production of rangeland, increasing soil humidity, changing the climate of the area, strengthening groundwater aquifers, helping species diversity, preventing soil erosion, creating temporary employment, preserving valuable species and developing livestock, can be achieved [10]. Yari et al. [38] reported that in the semi-circular bund area, soil erosion is significantly less than the abandoned and grazed areas, confirming better conditions of stability, soil permeability, and nutrient cycle in these areas, so that implementation of semi-circular bund project causes a significant increase in soil litter and cover Based on the results obtained in the Neron semi-circular bund, which is the habitat of *Ar. sieberi*, a significant increase in production and percentage of vegetation cover owing to the construction of the semi-circular bund was measured. Habitat conditions suggest that Naroon rangeland with lower plant production than Neron semi-circular bund is in a lower altitude range and includes the plain area, but with entering to *Ar. sieberi* habitat and moving towards *Ar. lehmania* habitat, conditions change to hills and mountains. In such conditions, it is expected that the height gradient to be more effective in this regard, and by entering the developed rainfall heights, the water requirements of the plants are met relatively.

Statistics of 23 rain gauge stations confirm this issue (11-year meteorological report of Khash city). Also, plants with a more humid environment have a stronger vegetative system, and there is a minor problem of humidity at high altitudes. In the Naroon semi-circular bund, precipitation affected by altitude gradient similar to mountain conditions does not occur, and plant growth depends only on normal precipitation. The *Z. eurypterum* habitat in the Neron semi-circular bund site is strongly affected by lack of humidity due to being located in the arid area, and the plants use most of their energy for the development of root organs to compensate for lack of humidity in cases of water shortage by increasing the absorption capacity [5]. One of the factors

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influencing the level of rainfall is the effect of altitude gradient [39]. In areas where rainfall is less than 500 mm, rainfall has the highest correlation with phytomass compared to other environmental factors [40]. In a rainy season, with increasing temperature, most soil humidity evaporates, and forb and grass species can rapidly absorb the soil moisture and develop their growth, but shrub species have the lowest efficiency in this field. Hence, the lowest plant cover development and green leaf production occur in them [41].

In general, the results of the analysis of variance revealed the positive effect of the semi-circular bund on vegetation characteristics. However, these characteristics had a higher increase in Neron semi-circular bund area (with more rainfall) than Naroon semi-circular bund. This comparison indicated that humidity restriction is a more influential factor in vegetation cover restriction and rangeland production in arid areas [42].

The effect on soil characteristics

Comparing acidity and electrical conductivity (Table 4) in the two semi-circular bund areas with the control areas (t-test) showed that Neron semi-circular bund was significantly different from the control area ($p<5\%$), so that the soil acidity in the Neron semi-circular bund area was lower than that of the control area, but soil salinity showed the opposite trend. However, Naroon semi-circular bund was not significantly different from its control in terms of these two factors. Concerning the percentage of clay, silt, and sand, which are the three determining factors of soil texture in an area, except for the percentage of clay in the Neron semi-circular bund area that had a significant increase compared to the control area ($p<5\%$), semi-circular bund areas were not significantly different with their control areas in terms of these three factors (Table 4). The results of comparing the factors influencing soil fertility (organic carbon, nitrogen, phosphorus, potassium, lime) in the semi-circular bund areas and control sites (t-test) showed that all these factors increased significantly in the semi-circular bund areas compared to the control sites ($p<5\%$).

Analysis of variance of soil characteristics (Table 4) indicated that all the studied characteristics were significantly different in the semi-circular bund areas and control areas ($p<5\%$). The highest levels of organic carbon, nitrogen, potassium, and lime belonged to Neron semi-circular bund. The lowest levels of organic carbon, nitrogen, and lime were measured in the Neron control. The highest value of phosphorus was measured in the Naroon control. The highest amount of clay belonged to the Naroon and Neron semi-circular bund, respectively, and the lowest level was measured in the control areas. The highest and lowest silt levels were measured in the Neron control area and Neron semi-circular bund area. The highest and lowest levels of sand were measured in the Naroon control area and Neron semi-circular bund area.

The diversity and abundance of perennial plant species in the semi-circular bund areas play a significant role in increasing soil fertility. Increasing soil nutrients in these areas indicate more accumulation of litter and more development of plant roots. This mechanism is due to increased vegetation, which results in a reduction in soil erosion and, consequently, trapping of nutrients carried by the wind [43, 44]. It should be noted that nutrient enhancement increases the plant litter and root mass additions to the soil [20]. The amounts of nitrogen, phosphorous, and potassium increased in the semi-circular bund areas. The higher soil nutrition in the semi-circular bund areas can be partially explained by the fact that the canopy cover of a plant is positively correlated with litter accumulation under its canopy [6].

Studies have indicated that with increasing vegetation arid areas, the level of nutrients trapped by the plant cover will increase. In contrast, in areas with less vegetation, the plants' efficiency to deposit nutrients transported to these areas by wind erosion will decrease, and even the nutrients of these soils are easily moved by the wind and will lead to reduced soil fertility in these areas [45,46]. Lower radiation under canopy cover of plant species reduces soil temperature and

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Table 4) Characteristics of soil sampled at the study area.

Soil properties	Naroon	Control	Neron	Control
ECE (dS m^{-1})	0.20±0.00^{Aa}	0.20±0.00^{Aa}	0.20±0.00^{Aa}	0.13±0.05^{Bb}
pH	8.20±0.02^{Ba}	8.19±0.02^{Ba}	8.86±0.23^{Ab}	8.01±0.046^{Ba}
Organic carbon (%)	0.26±0.00^{Ab}	0.09±0.05^{Bc}	0.80±0.01^{Aa}	0.30±0.17^{Bb}
Nitrogen (%)	0.02±0.00^{Ac}	0.01±0.00^{Bd}	9.60±0.57^{Aa}	8.33±3.00^{Bb}
Phosphorus (mg kg^1)	8.40±1.50^{Aa}	7.53±0.46^{Bb}	0.07±0.00^{Ac}	0.03±0.01^{Bd}
Potassium (mg kg^1)	391.00±12.12^{Ac}	367.00±39.55^{Bb}	613.33±9.23^{Aa}	300.67±10.50^{Bd}
$CaCO_3$ (%)	20.00±6.35^{Aa}	13.76±3.40^{Bb}	21.56±0.80^{Aa}	20.30±2.25^{Aa}
Silt (%)	27.33±1.15^{Ab}	26.66±1.15^{Ab}	34.33±1.15^{Aa}	38.00±0.00^{Aa}
Sand (%)	61.33±1.15^{Aa}	64.33±1.15^{Aa}	52.66±2.30^{Ab}	54.33±1.15^{Ab}
Clay (%)	12.00±0.00^{Ab}	9.00±0.00^{Ab}	13.66±1.15^{Aa}	7.66±1.15^{Bb}

*Values shown are the means± SE. Different capital case letters in each row indicate significant differences with controls (p‹0.05, t-Test). Different lower letters in each row indicate significant differences among treatments (p‹0.05, post hoc Duncan test).

evaporative water losses. In contrast, higher organic matter content improves soil water retention, thereby causing soil moisture and litter decomposition rates to be higher under plant canopies than in the areas without vegetation [42]. Thus, more litter accumulation may have contributed to the higher fertility of the soils for a long time.

Analysis of data variance showed that the soil of the Neron semi-circular bund was more fertile than Naroon semi-circular bund and control areas. As stated earlier, its most important reason can be attributed to the vegetation and more production in this area, since with the development of vegetation, sunlight radiation under the vegetation will be relatively less, leading to a reduced rate of evaporation and loss of water and also increased content of soil organic matter. By increasing the humidity level in these areas, the speed of litter decomposition will increase, and it will increase soil fertility [43]. Also, in the semi-circular bund areas, compared to the control areas, the percentage of silt and clay in these areas increased significantly. Results have shown that the deposition of soil particles carried by the wind is highly associated with the development of vegetation cover [46]. With the establishment of plants and increasing the cover of plant foliage, the percentage of fine soil particles deposited by the vegetation cover and in space around plants will be higher [3]. Given the characteristics of this aggregate, such as high specific surface area and nutrient storage capacity, their limited increase can be considered a positive move. However, it is necessary to investigate its long-term changes and the possibility of soil hardness and reduced water uptake by plants due to high clay storage potential.

Conclusion

The result of the study indicated that the semi-circular bund significantly changed the habitat characteristics and resulted in vegetation richness in the arid rangeland of Khas. The numbers of palatable species were more in the semi-circular bund areas than the control areas. Canopy cover and richness were increased as well as the plant production in the semi-circular bund areas. The results indicated that the semi-circular bund operation could increase soil fertility in terms of nitrogen, organic matter, and potassium in the arid rangelands. In conclusion, a semi-circular bund can be an effective tool to enhance diversity and improve soil quality. However, more studies are needed to assess the effect of the improvement operations on the reclamation of rangelands in arid ecosystems.

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Conflict of Interest
The author declares that there are no conflicts of interest regarding the publication of this manuscript.

Acknowledgments
The author expresses her thanks to the Department of Range and Watershed Management, University of Zabol, for providing the necessary facilities to undertake this study.
Funding/Support
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sector.

References

1. Al-Rowaily S.L., El-Bana M.I., Al-Bakre D.A., Assaeed A.M., Hegazy A.K., Ali M.B. Effects of open grazing and livestock exclusion on floristic composition and diversity in natural ecosystem of Western Saudi Arabia. Saudi J. Biol. Sci. 2015; 22(4): 430-437.
2. Faraji F., Alijanpour A., Sheidai Karkaj E., Motamedi J. Effect of fire and rangeland banqueting on soil carbon sequestration in Atbatan summer rangelands, East Azerbaijan Province. ECOPERSIA 2019; 7(1): 29-37.
3. Khosravi H., Ebrahimi M., Rigi M. Effects of rangeland exclusion on plant cover and soil properties in a steppe rangeland of Southeastern Iran. Arid. Land Res. Manag. 2017; 31(3):352-371.
4. McSherry M.E., Ritchie M.E. Effects of grazing on grassland soil carbon: a global review. GCB Bioenergy. 2013; 19(5): 1347-1357.
5. Ebrahim M., Mohammadi F., Fakhireh A., Bameri A. Effect of *Haloxylon* spp. with different age classes on vegetation cover and soil properties in an arid desert steppe of Iran. Pedosphere 2019; 29(5): 619-631.
6. Jafari M., Ebrahimi M., Azarnivand H. Madahi A. The effects of rangeland restoration treatments on some aspects of soil and vegetation parameters (Case study: Sirjan rangelands). J. Rangeland 2009; 3 (3): 371-384 (In Persian).
7. Arab M. Effect of the improvement operations on ecological indexes of rangeland health using landscape function analysis method in Jiroft rangelands. M.Sc. Thesis in Range Management, University of Zabol, Iran. 2013. 101p (In Persian).
8. Ebrahimi M., Khosravi H., Rigi M. Short-term grazing exclusion from heavy livestock rangelands affects vegetation cover and soil properties in natural ecosystems of southeastern Iran. Ecol. Eng. 2016; 95(1): 10-18.
9. Khosravi H. Effect of improvement operations on reclamation of soil and vegetation cover in Taftan rangelands. M.Sc. Thesis in Range Management, University of Zabol, Iran. 2012; 101p (In Persian).
10. Delavari A., Bashari H., Tarkesh M. Mirkazehi A., Mosadeghi M.R. Evaluating the effects of semicircular bunds on soil surface functionality using Landscape Function Analysis. J. Rangeland. 2014; 8(3): 251-260 (In Persian).
11. Ata Rezaei A., Arzani H., Tongway D. Assessing rangeland capability in Iran using landscape function indices based on soil surface attributes. J. Arid Environ. 2006; 65(3): 460-473.
12. Report of Rangeland Improvement, Koteh, Sistan, and Baluchestan. Agriculture and Natural. Resources Center, Sistan and Baluchestan. 2010 (In Persian).
13. Cain S.A. The Species-Area Curve. Am. Midl. Nat. 1938; 19(3): 573-581.
14. Hanley T.A. A comparison of the line-interception and quadrat estimation methods of determining shrub canopy coverage. J. Range. Manag. 1978; 31(1): 60-62.
15. Coulloudon B., Eshelman K., Gianola J., Habich N., Hughes L., Johnson C., Pellant M., Podborny P., Rasmussen A., Robles B., Shaver P., Spehar J., Willoughby J. Sampling vegetation attributes. Technical Reference, Grazing Land Technology Institute. Denver, Colorado. 1999. 171 p.
16. Heath M.E., Barnes R.F., Metcalfe D.S. Forages: The science of grassland agriculture. Iowa State University, Iowa, 2003. 576 p.
17. Baghestani N., Arzani H., Zare T., Abdollahi J. Study of forage quality the important species of stepic rangeland of Poshtkhoeh Yazd. Iran. J. Range Desert Res. 2001; 11(1): 137-162 (In Persian).
18. Arzani H., Zohdi M., Fish E., Zahedi A., Nikkhah G.A, Wester D. Phenolojical effects on forage quality of five grass species. J. Range Manag. 2004; 57(6): 624-630.
19. Bagheri H., Adnani M., Tavili A. Studying the relationship between livestock and plant composition Case study: semi steppic ranges of Vesf-Qom Province. Pajouhesh and Sazandegi. 2007; 20(1): 155-162 (In Persian).
20. Zhang T.H., Su Y.Z., Cui J.Y., Zhang Z.H., Chang X.X. A leguminous shrub (*Caragana microphylla*) in semi-arid sandy plain of north China. Pedosphere 2006; 16(3): 319-325.
21. Jiang G., Xingguo H., Jianguo W. Restoration and management of the Inner Mongolia grassland require a sustainable strategy. Ambio. 2006; 35(5): 269-270.
22. Wang A., Luo C., Yang R., Chen Y., Shen Z., Li X. Metal leaching along soil profiles after the EDDS application–A field study. Environ. Pollut. 2012;

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164(1): 204-210.

23. Thomas G.W. Soil pH and soil acidity. In: Sparks D.L (ed.). Methods of soil analysis, American Society of Agronomy, Soil Science Society of America, Madison, Wisconsin; 1996;1(1):475-490.
24. Rhoades J.D. Salinity: Electrical conductivity and total dissolved solids. In: Page A.L (ed.). Methods of soil analysis, American Society of Agronomy, Madison, Wisconsin; 1996;1(1): 417-435.
25. Lo I., Tsang D., Yip T., Wang F., Zhang W.H. Influence of injection conditions on EDDS-flushing of metal-contaminated soil. J. Hazard Mater. 2011; 192(2): 667-675.
26. Bray R.H., Kurtz L.T. Determination of total, organic and available forms of phosphorus in soils. Eur. J. Soil Sci. 1954;59(1): 39-45.
27. Suganuma M.S., de Assis G.B., Durigan G. Changes in plant species composition and functional traits along the successional trajectory of a restored patch of Atlantic forest. Community Ecol. 2014; 15(1): 27-36.
28. Rodrigues R.R., Lima R.A. F., Gandolfi S., Nave A.G. On the restoration of high diversity forests: 30 years of experience in the Brazilian Atlantic Forest. Biol. Conserv. 2009; 142(1): 1242-1251.
29. Zhou G., Wei Q., Li B., Zeng X., Liu G. Establishment and optimization of a hydroponic system for root morphological and nutritional analysis of citrus. Soil Sci. J. Plant Nutr. 2020; 77(4): 2-11.
30. Jafarian A., Jafari M., Tavili M. Assessment of *Haloxylon* plantation effects for desert reclamation with emphasis on substratum's soil and vegetation properties in Kale Shoor of Sabzevar region, Iran. Iran. J. Range Desert Res. 2014; 21(1): 51-61(In Persian).
31. El-Keblawy A., Ksiksi T. Artificial forests as conservation sites for the native flora of the UAE. For. Ecol. Manag. 2005; 213(1-3): 288-296.
32. Vetaas O.R. Micro-site effects of trees and shrubs in dry savannas. Int. J. Veg. Sci. 1992; 3(3): 337-344.
33. Stinca A., Battista Chirico G., Incerti G., Bonanomi G. Regime shift by an exotic nitrogen-fixing shrub mediates plant facilitation in primary succession. PLoS One. 2015; 10(4): e0123128.
34. Rokhfirooz G., Ghorbani J., Shokri M., Jafarian Jelodar Z. Effect of rangeland rehabilitation and restoration on composition and diversity of species seeds in the soil. Iran. J. Range Desert Res. 2011; 18 (2): 322-335 (In Persian).
35. Yari R., Tavili A., Zare S. Investigation on soil surface indicators and rangeland functional attributes by Landscape Function Analysis (LFA) (Case study: Sarchah Amari Birjand). Iran. J. Range Desert Res. 2012; 18(4): 624-636 (In Persian).
36. Javidfar A., Rouhi-Moghaddam E., Ebrahimi M. Some ecological conditions of *Amygdalus scoparia* Spach in Nehbandan, Eastern Iran. ECOPERSIA 2017; 5(1): 1655-1667.
37. Barker D.J., Dodd M.B., Wedderburn M.E. Plant diversity effect on herbage production and compositional changes in New Zealand hill country pastures. Grass Forage Sci. 2004; 59(1): 12-29.
38. Jobbágy E.G., Osvaldo E.S. Controls of grass and shrub aboveground production in the Patagonian steppe. Ecol. Appl. 2000;10(2): 541-549.
39. Aguilera E., Gutiérrez J.R., Meserve P.L. Variation in soil micro-organisms and nutrients underneath and outside the canopy of *Adesmia bedwellii* (Papilionaceae) shrubs in arid coastal Chile following drought and above average rainfall. J. Arid Environ. 1999; 42(1): 61-70.
40. Rathore V.S., Singh J.P., Bhardwaj S., Nathawat N.S., Mahesh Kumar M., Roy M. Potential of native shrubs *Haloxylon salicornicum* and *Calligonum polygonoides* for restoration of degraded lands in arid western Rajasthan, India. J. Environ. Manage. 2015; 55(1): 205-216.
41. Hashemi Rad M., Ebrahimi M., Shirmohammadi E. Land use change effects on plant and soil properties in a mountainous region of Iran. Glob. J. Environ. Sci. Manage. 2018; 21(2): 47-56.
42. Li X., He M.Z., Jia R.L. The response of desert plant species diversity to the changes in soil water content in the middle-lower reaches of the Heihe River (In Chinese). J. Adv. Earth Sci. 2008; 23(7): 685-696.
43. Gonzales E.K., Clements D.R. Plant community biomass shifts in response to mowing and fencing in invaded oak meadows with non-native grasses and abundant ungulates. Restor. Ecol. 2010; 18(5): 753-761.

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