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Environmental Factors Affecting the Structural Trials and Biomass of *Onobrychis aurea* Bioss

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ABSTRACT

Aims Recognizing the environmental factors affecting plants structural trials and biomass is important to conserve plants as well as their ecosystem function, and services. *Onobrychis aurea* is a valuable forage that is distributed in the marl lands and is considered as an endangered plant species in Iran. In the present study, the ecological characteristics (plant traits) of this species has been investigated in detail.
Materials & Methods For this purpose, structural traits and biomass of *O. aurea* were investigated in 12 ecological units with different topographical and soil conditions. Three soil samples were taken to 15cm depth, (0-15cm) in each ecological unit. The relationship between structural traits and species biomass with environmental factors was tested by redundancy analysis (RDA) method in 2016.
Findings The results indicated that the soil characteristics including clay, lime and silt content play a more important role in the structural and biomass traits of *O. aurea* evidence show. Spatial and topographical factors, especially elevation and geographical aspects, had a smaller contribution in structural traits and species biomass in comparison with soil factors. Higher structural values were recorded in heavy textured alkaline soils. The slope percentages also have no significant effect on plant characteristics.
Conclusion The present study indicated that the soil and topographic factors are very important for management of *O. aurea*. In general, it should also be emphasized that having good knowledge related to plant ecology as well as environmental condition could help managers to conserve and rehabilitate endangered plants.

Keywords Plant Characteristics; Marl Lands; Semi-Arid Rangelands; Functional Diversity

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Introduction

Plants have various functional traits from tissue to organ level, reflecting their evolutionary history and shape as well as their function in the environment [1]. Understanding these traits is the first step to recognize the present patterns and responses to environmental conditions [2, 3].

Vegetation traits, depending on important plant organs (leaf, stem, and underground organs), have various measuring units and variation ranges [4] and divided into three groups including plant stability, reproduction, and distribution [5].

Seed numbers, seed size as well as soil seed bank represent plant reproduction traits and determine germination vigor, competition power, and plant destruction [4].

Plant traits determine the plant response to biotic and abiotic environmental conditions. For instance, the life forms available in a plant community have a great determinative impact on biogeochemical cycles of ecosystem (material degradation and cycle) and destructive regimes. In most cases, the impact is very high that the response of plant community against environmental conditions and ecosystem performance in terms of materials cycles could be found by studying only one or several prominent traits of plant community [6, 7].

Over the past decade, the study of functional properties of living organisms (instead of taxonomic classification) improved to establish general rules regarding the dynamics of the ecosystem in response to environmental changes [8]. Accordingly, it is emphasized that the study of the relationship between biological properties of the plants and environmental factors is very important [9]. On the other hand, the response of different types of plants or individual plant to disturbances and environmental factors leads to the definition of the response groups.

Functional traits are different measurable morphological, physiological or phenological forms that can be continuous or classified [10]. In this regard, it is reported that the plant characteristics that interact with the environment can be classified in terms of their response to environmental changes (response attributes), or in terms of impacts affecting the community or ecosystem properties (effects traits) [8, 10].

Functional traits provide a comprehensive framework for the interpretation of changes in plant communities along with environmental gradient [11]. These traits should be related ecologically in terms of processes and desired scale (e.g. climate, soil quality, grazing, fire, etc.). The best set of traits are those that provide the highest and most complete information about the ecosystem services and could be measured easily [12].

Many ecological patterns are generally scale-dependent, and the habitats of plant species can measure across a broad range of ecological scales, with distinct environment gradients, indicating that the amount of trait variation would differ among different scales [13]. There are many studies examining the relationship between vegetation biomass and environmental conditions. As an example, Peng *et al.* [14] found that net primary production responds non-linearly to the increased or/and decreased rainfall in semi-arid grassland ecosystem. Chang *et al.* [15] also indicated that annual precipitation and air temperature are the key factors affecting the aboveground net primary productivity (ANPP) in temperate grasslands, and hold that ANPP increased with the increasing of precipitation, and declined with the air temperature. Fan *et al.* [16] reported that the amount of belowground biomass increased when temperature decreased. A number of studies have demonstrated strong linear relationships between vein traits of various plant species and their leaf hydraulic conductance, photosynthetic, anatomical, and compositional traits, which generally influence the flux of water and carbon into and out of leaves [17, 18]. The research has indicated that species traits, rather than species identity, determine the responses of a species to environmental changes [19, 20]. It has been argued that trait-based approaches could provide a better understanding of the important factors behind spatiotemporal shifts in community composition [21].

Trait-based approaches have been used successfully to evaluate complex ecosystem responses to human-induced environmental disturbance in grasslands [22, 23] and forest ecosystems [24, 25]. But to date, there are few studies to indicate the plant structural and biomass traits responses to environmental conditions in semi-arid rangelands. Recognition of various response trait types could be a useful tool to evaluate the long-term changes in management systems. Also, various functions of

plants could be utilized as indices of vegetation changes in association with environmental and management factors as well as rangelands stability indices [26]. Thus, understanding and better prediction of the behavior of response functional groups is necessary to minimize the decrease in species diversity and potential ecosystem flexibility [27].
Furthermore, there is a question, what is the relationship between these characteristics and environmental and managerial factors?. Accordingly, in the present study, ecological relation of structural traits and biomass of *O. aurea* with environmental factors is evaluated. *O. aurea* is a valuable forage that is distributed in the marl lands and is considered as an endangered plant species in Iran [28].
In the present study, it is hypothesized that the structural and biomass traits of *O. aurea* are mainly affected by soil factors as well as topographical conditions.

Materials and Methods

Khajeh research grazing exclusion with a total area of 340 hectares was selected as evidence of distribution of *O. aurea* (Family of Fabaceae) that is located in marl lands of semi-arid rangelands of Azerbaijan (North West Iran). The rangeland has been protected from grazing around two decades the first report of *O. aurea* was documented in 2004 from this area in Iran [29].
O. aurea has considerable distribution in different geographical directions of the heights of the region, especially the northern and southern slopes, the flat regions of the ridge, and the floor of the canals (V-shaped canals). The area was divided to different ecological units according to the form of plant distribution as well as geographical condition (Figure 1).
The study area is located between latitudes 46°38'4'' to 46°40'17'' E and longitudes 38°9'9'' to 38°10'25'' N, at an elevation of 1500-1620 above sea level (Figure 1). Total annual precipitation and mean temperature in the area were 244.3mm and 13.4°C, respectively. According to de Martonne aridity index, the area has a semi-arid climate.
12 ecological units have been considered for sampling (Table 1 and Figures 2 and 3). The ecological units were distinguished based on environmental condition of topographic factors especially elevation gradient. This species distributes on the northern and southern slopes. Meanwhile, in addition, flat areas of ridge and the floor of the V-shaped valleys also have a significant occurrence of the species. All possible habitats of this species were identified by extensive and intense field surveys in the region.
A systematic randomized method was used to estimate the vegetation distribution and cover in the study area. Three line transects (50m) were considered in each ecological unit and depending on the situation of each ecological unit, the inter-transect intervals were 15 to 30 meters. In total, 180 one m^2 plots were used along 36 line transects [30].
After establishing the sampling network in each ecological unit, the number of bases and the percentage of crown (canopy) cover were recorded for each species located inside the plots (one m^2). In addition, *O. aurea* in each plot were cut one centimeter above the ground and weighted.
Simultaneously with vegetation measurements, 15 healthy, strong, and well-grown stands of *O. aurea*, receiving sufficient light, were selected in each ecological unit to measure vegetation characteristics. Plant characteristics measured at this stage were included 23 structural traits and six biomass traits (Table 2) according to Cornelissen *et al.* [4]. Besides, in order to better visualize the traits mentioned in Table 2, the schematic and natural image of *O. aurea* is presented in Figure 4.

In the next step, in order to study the effect of soil factors on distribution of dominate species and its relation with plant traits, a soil sample was collected from the middle of each transect in three replications up to the rooting depth (0-15cm). Physical and chemical properties including clay, silt and sand percent, pH, bulk density, and electrical conductivity were measured according to Carter and Gregorich [31].
The percentage of slope, geographic direction and elevation of each location were also considered as topographic factors.
Multivariate analysis was used to determine the relationship between environmental factors. As dependent and independent variables plant characteristics (structural traits and biomass) and soil and topographic parameters were considered, respectively. For this purpose, in the first step, the values of plant characteristics were summarized in primary matrix. The rows consist of the number of stands and the columns include the values of the attributes. Also,

environmental factors were summarized in the matrix a secondary matrix which rows contain the number of stands and its columns including physical and chemical properties of the soil and topographic properties. In the second step, the detrended correspondence analysis (DCA) as a multivariate statistical technique was applied to estimate the environmental data and plant traits (response data). According to the length of the gradient, which was less than 3, the redundancy analysis (RDA) method was used as a linear method. In addition, by performing the Monte Carlo test with 999 repetitions and regarding to the F statistics-ratio and p-values, the total model's significance was evaluated [32]. All statistical calculations were done using SPSS 21 and Canoco 5.0.

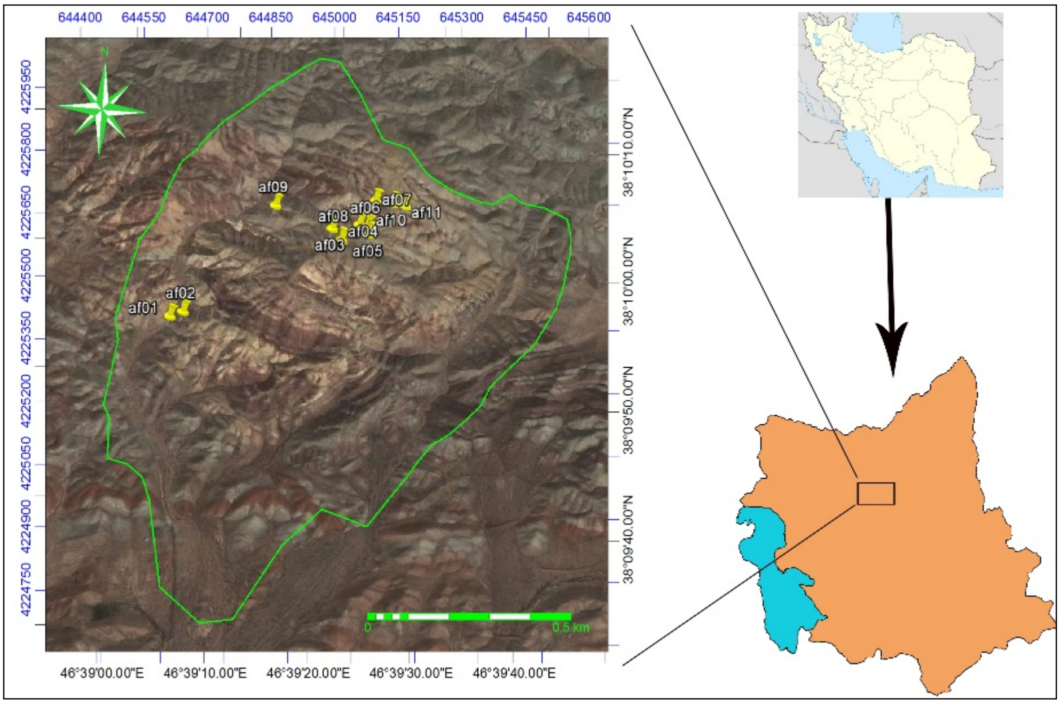

Figure 1) Geographical location of the study area

Table 1) Physical properties of the sites surveyed

Ecological units	**Area** (ha)	**Elevation range** (m)	**Position of the study unit**	**Dominant Slope** (Degree)	**Land unit**	**Soil texture**	**Canopy cover** (%)	**Stone and pebble** (%)	**Land unit**	**Soil texture**
1	0.08	1553	North	60	brae	Silty-clay-loamy	30.8	9.3	brae	Silty-clay-loamy
2	0.09	1543	Valley	50	Valley	Silty-clay-loamy	27.5	7	Valley	Silty-clay-loamy
3	0.1	1639	No direction	7	Crest	Silty-loamy	42	7	Crest	Silty-loamy
4	0.09	1641	No direction	4	Crest	Silty-clay-loamy	44.4	10	Crest	Silty-clay-loamy
5	0.1	1629	No direction	6	Crest	loamy	41.8	7.7	Crest	loamy
6	0.08	1640	Valley	17	Valley	loamy	46.9	6.3	Valley	loamy
7	0.1	1632	South	24	brae	loamy	33.8	15.2	brae	loamy
8	0.08	1641	Valley	25	Valley	loamy	51.3	7.5	Valley	loamy
9	0.15	1535	North	30	brae	loamy	45.9	16	brae	loamy
10	0.1	1637	North	18	brae	loamy	41.6	18.5	brae	loamy
11	0.12	1636	South	25	brae	loamy	37	16	brae	loamy
12	0.15	1657	South	28	brae	Silty-loamy	37.3	12.7	brae	Silty-loamy

Figure 2) Landscapes from ecological sites in ridge and floor of V-shaped valley

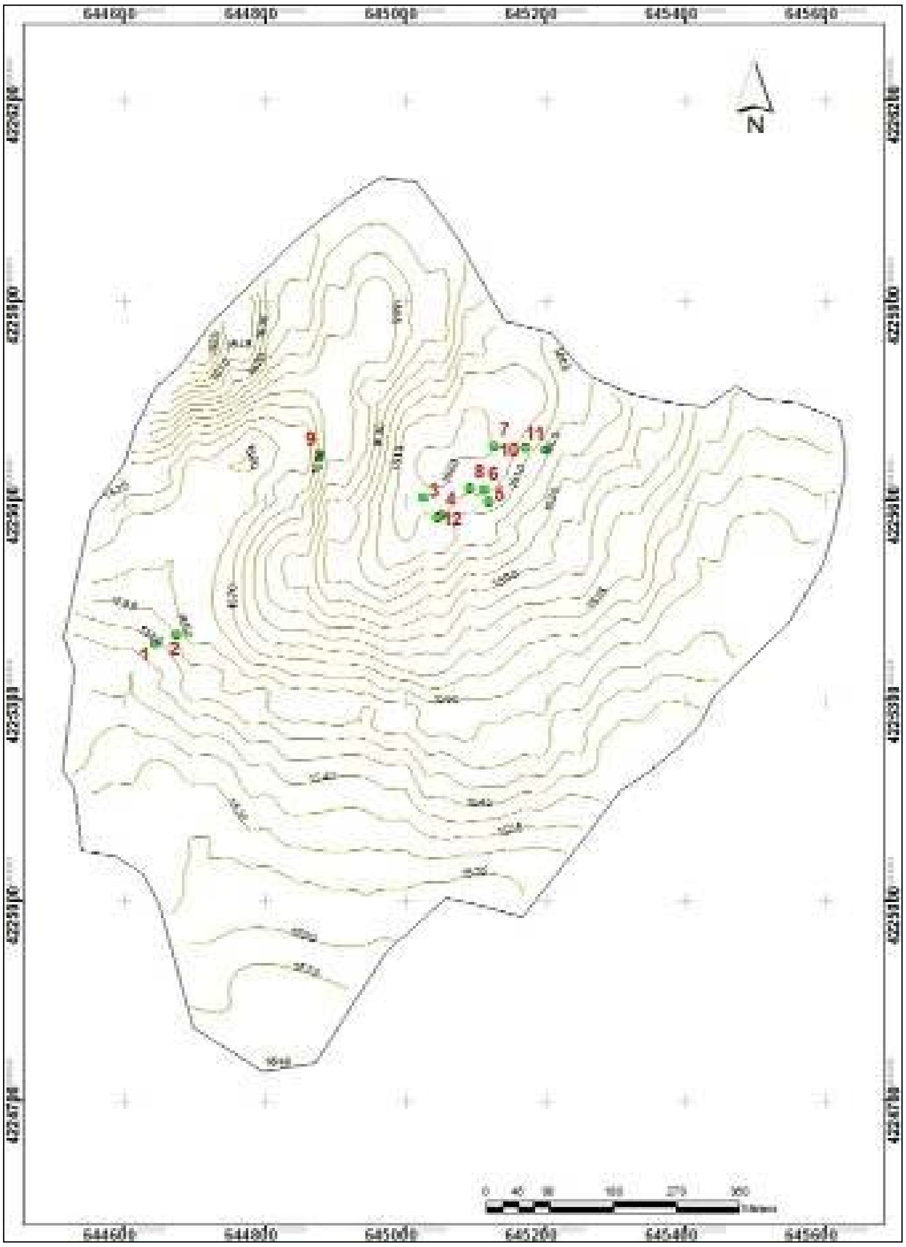

Figure 3) Schematic image of the distribution of the studied units

Table 2) Structural and biomass traits of *O. aurea*

Traits
Structural traits
Large and small diameter crown diameter
Large and small diameter of the collar
Number of vegetative and reproductive sprouts
Number of leaves of vegetative and reproductive sprouts
Number of compound leaves with terminal leaflet
Number of compound leaves
The length of compound leaves
The length of compound leaves with terminal leaflet
The number of inflorescences
The inflorescence main axe length
The number of leaflets
The mean leaflet length
The mean leaflet width
The mean leaflet area
The mean height of sprout
The mean root length
The mean number of seeds per plant
Average crown cover
Density or number of stands in 10 square meters
Biomass traits
Dry weight of biomass of each stand
The average weight of seed per plant
Production per unit area (grams per 10 square meters)
The average dry weight of leaflets
The total dry weight of leaflets
The average root dry weight of each stand

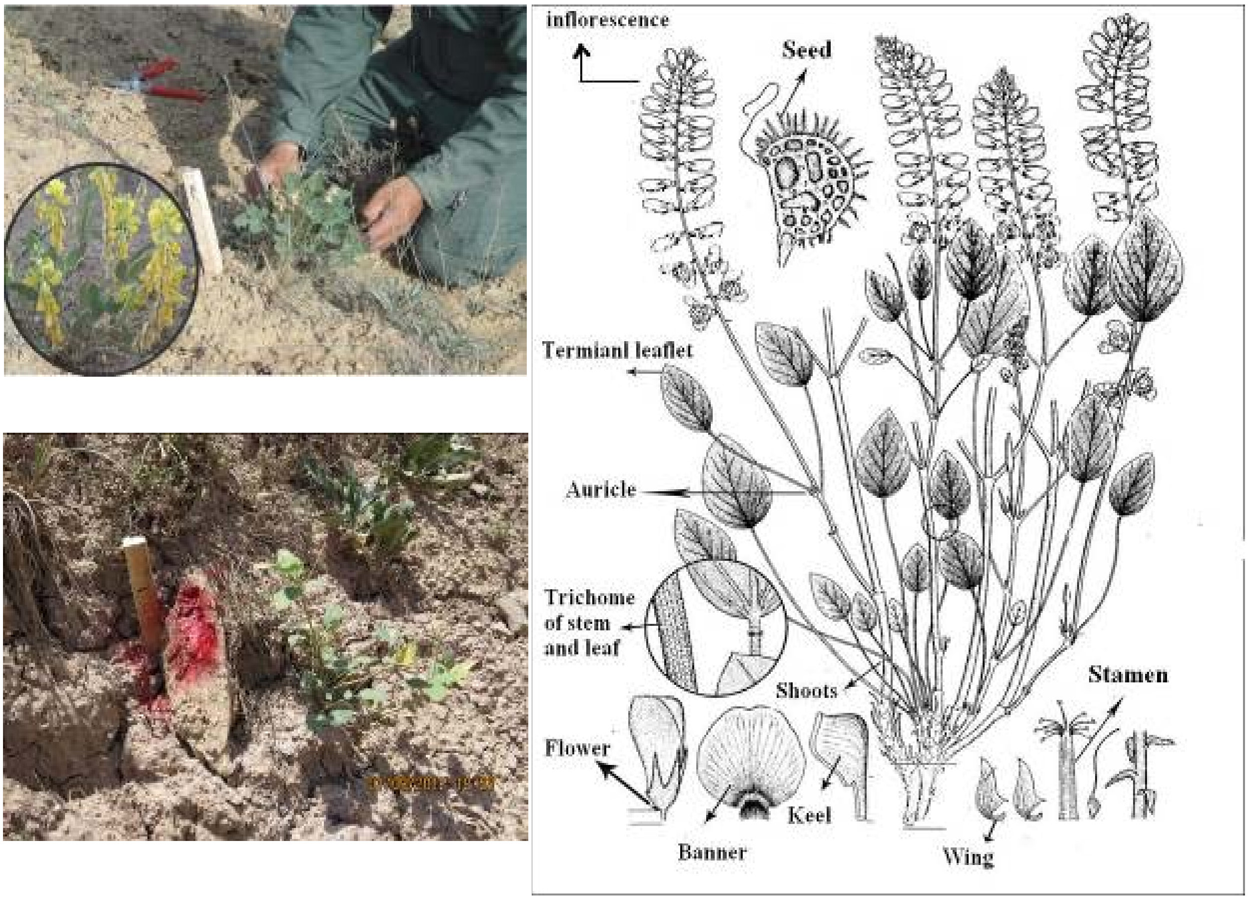

Figure 4) Schematic representation (right) [29] and field representation (left) of *O. aurea* (Auhors)

Findings

Important soil physical and chemical properties from the study area are presented in Table 3. According to particle size classifications, soils of the study areas are generally loamy to loamy clay. The results show that clay and silt content a larger share of soil texture. As expected, due to the geomorphological condition, the percentage of limestone in soil samples is also high. Lime is one of the stable compounds in arid and semi-arid regions, transferred from the decomposition of limestone and marl to soils and remains unaltered for a long time. The results also depict that the soil is classified as weak alkaline soils. The average soil electrical conductivity is 2.48mmhos/cm, which according to the classification of saline and alkaline soils (Halomouf), is classified as low salinity soils. The physical properties of the soil are usually difficult to change, but these changes are largely visible in marl land soils [33].

Table 3) Average of some physical and chemical soil properties of the investigation area

Variable	Mean±SE
Electrical conductivity (mmhos/cm)	2.48±0.019
Acidity	7.87±0.05
Lime (%)	20.35±1.72
Organic carbon (%)	0.42±0.014
Clay (%)	41.67±6.64
Silt (%)	33.17±8.30
Sand (%)	25.17±7.98
Porosity (%)	39.38±2.92
Gravel (%)	33.08±10.82
Bulk density (g/cm^3)	1.61±0.08
Gypsum (meq/100g)	367.88±76.27
Elevation	1615.25±42.89
Slope (degree)	26.17±20.66
Modified slope direction	0.74±0.25

Vegetation measurement results showed that the average canopy cover of *O. aurea* was 4.6%. Thus, its relative frequency in the plant community composition of the study sites is 12.1%. Its density is 31.8 base per hectare and its production amount is 7.9kg.ha^{-1}. The mean and the standard error for structural traits and biomass are presented in Tables 4 and 5.

Based on the results of linear redundancy analysis (RDA), the first and second axes could explain 67% of variance of structural traits. Accordingly, the first and second axes show the highest relationship between environmental factors effects and structural traits of *O. aurea*, which were used to represent the results of these two axes (Diagram 1).

The characteristics associated with the structural traits of the studied bases, such as the average length of combined leaf with the terminal leaflet, the mean height of the stand, the average crown cover percent, the mean leaf area, the mean width of the leaf, the mean length of the inflorescence axis, the crown diameter, and the mean leaflet length are most affected by the soil silt content of the ecological units.

The number of leaves with a terminal leaflet, number of reproductive leaves, number of reproductive stands, mean number of leaflets, number of inflorescences, crown diameter, and average seed number of each base are also more affected by the lime content in the ecological units and are less affected by topographic factors (aspect and elevation of ecological units). Clay content of ecological units is the most important environmental factor, affecting the number of compound leaves, small diameter of collar, large diameter of collar, the number of vegetative sprouts, the number of leaves of vegetative sprouts, the mean root length, and density. According to the results, clay, lime content, and silt percentage are the main factors affecting structural traits, respectively. Accordingly, the values of the structural properties of *O. aurea* are higher in heavy calcareous soils. Topographic factors (elevation and geographic direction of ecological units) have a smaller contribution than soil factors on the structural characteristics of the species studied.

Table 4) Descriptive information of structural traits of *O. aurea*

Trait (Plant characteristics)	Mean±SE
Large crown diameter (cm)	23.45±3.81
Small crown diameter (cm)	13.03±2.97
Large collar diameter (cm)	7.06±2.43
Small collar diameter (cm)	3.43±1.28
Vegetative stands number	0.79±0.60
Reproductive stands number	3.96±1.34
Vegetative leaf number	3.18±2.76
Reproductive leaf number	14.55±4.67
Number of compound leave with a terminal leaflet	4.7±1.4
Number of compound leave	12.98±4.20
Length of compound leave with a terminal leaflet (cm)	4.0±1.77
Length of compound leave	6.3±0.99
Inflorescence number	7.7±2.53
Length of inflorescence axis (cm)	8.2±2.13
Stands leaflets number	21.5±4.99
Mean length of leaflets (cm)	2.9±0.22
Mean width of leaflets (cm)	1.7±0.14
Mean area of leaflets (cm^2)	4.0±0.57
Mean height of stands (cm)	17.8±3.36
Mean root length (cm)	49.3±12.46
Mean seed number per stand	7.6±4.12
Mean crown cover (%)	4.6±1.25
Density (stand per $10m^2$)	7.95±3.21

Table 5) Descriptive information of biomass traits of *O. aurea*

Trait (Plant characteristics)	Mean±SE
Biomass dry weight of each stand (g)	5.59±2.15
Mean weight of seed of each stand (g)	0.30±0.17
Yield per area (g per 10m^2)	31.8±15.97
Mean dry weight of leaflets of each stand (g)	0.47±0.07
Total dry weight of leaflets of each stand (g)	77.29±17.19
Mean dry weight of root of each stand (g)	10.25±4.92

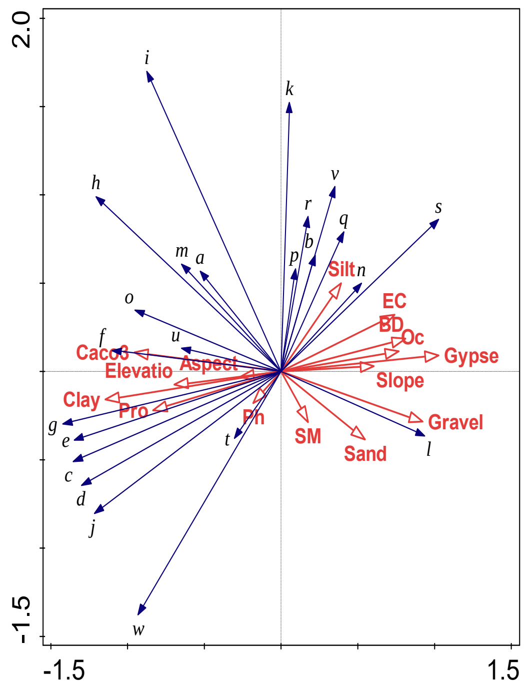

Diagram 1) Relationship between structural traits and environmental factors using Redundancy analysis; k: The average length of combined leaf with the terminal leaflet; s: The mean height of the stand; v: The average crown cover percent ; r: The mean leaf area; q: The mean width of the leaf ; n: The mean length of the inflorescence axis; b: The crown diameter; p: The mean leaflet length; l: Terminal leaflet; h: Number of reproductive leaves; f: Number of reproductive stands; o: Mean number of leaflets; m: Number of inflorescences; a: Crown diameter; u: Average seed number of each base; $CaCO_3$: The lime percentage; j: The number of compound leaves; d: Small diameter of collar; c: Large diameter of collar; e: The number of vegetative sprouts; g: The number of leaves of vegetative sprouts; t: The mean root length; w: density; Silt: Silt percentage; i: The length of compound leave; SM: Saturation moisture percentage; Pro: Porosity percentage; Gypse: Gypsum content; Gravel: Gravel percentage; Sand: Sand percentage; Clay: Clay percentage; BD: Bulk density; Oc: Organic carbon percentage; EC: Electrical conductivity content; Elevatio: Elevation; pH: Acidity; Aspect: Modified slope direction; Slope: Slope degree

By performing the Monte Carlo test, the significance of the whole model was evaluated by F statistics-ratio and p-value with 999 repetitions [32]. Therefore, the results of redundancy analysis showed that the relationship between environmental factors and structural traits was significant at 0.01% level (F statistics-value ratio= 3.2; p= 0.004).

Based on the results of linear redundancy analysis (RDA), the first and second axes could explain 78% of variance of relationship between environmental factors and biomass traits. The biomass traits such as average root dry weight, average dry weight of each leaflet, total dry weight of leaflets, and average weight of seed per base, were most affected by saturation moisture percentage and porosity in the soil of study units (Diagram 2).

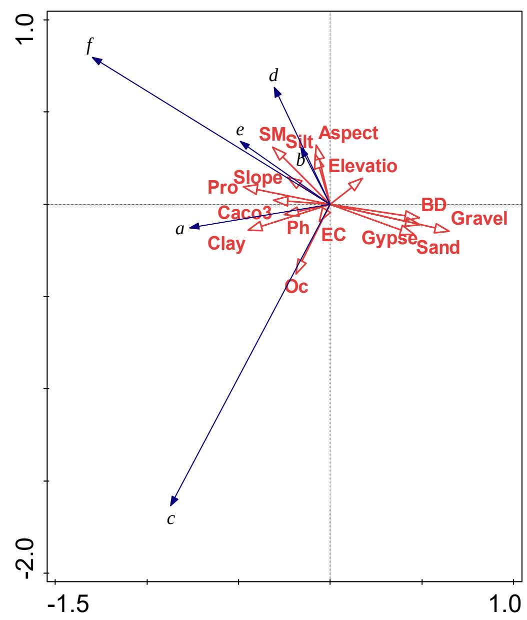

Diagram 2) Relationship between biomass traits and environmental factors using Redundancy analysis; f: Average root dry weight; d: Average dry weight of each leaflet; e: Total dry weight of leaflets; b: Average weight of seed per base; SM: Saturation moisture percentage; Pro: Porosity percentage; Gypse: Gypsum content; Gravel: Gravel percentage; Sand: Sand percentage; BD: Bulk density; a: Biomass dry weight of each stand; c: Yield per area; Oc: Organic carbon percentage; EC: Electrical conductivity content; Elevatio: Elevation; pH: Acidity; Aspect: Modified slope direction; Silt: Silt percentage; Clay: Clay percentage; Slope: Slope degree; $CaCo_3$: Lime percentage

Soil organic matter (SOM) is also the most effective factor in the amount of aerial biomass of the species studied per area unit. Generally, the organic matter content, saturation moisture percentage and soil porosity are the factors affecting the biomass characteristics of the species. Accordingly, *Onobrychis aurea* had more aerial biomass in fertile soils and had higher seed production and underground biomass in the soils having higher porosity and saturation moisture content. In contrast, soil parameters including gypsum content, gravel percentage, sand percentage, and bulk density had a limiting role on total dry weight of leaflets and average root dry weight. Similar to the results of structural characteristics, topographic factors had less contribution to biomass traits than on soil factors. The slope percentage had little or no effect on any plant characteristics (structural traits and biomass). Overall, soil factors, in comparison to topographic factors, contributed more in the structural traits and biomass (vegetation characteristics) of *O. aurea* in the habitats studied.

By performing the Monte Carlo test, the significance of the whole model was evaluated by F statistics-ratio and p-value with 999 repetitions. Therefore, the results of Canonical Correspondence Analysis showed that the effect of environmental factors on biomass traits was significant (F statistics-value ratio= 2.8; p= 0.003).

Discussion

The study of relationships between the structural traits of *O. aurea* with the environmental factors showed that clay, lime and silt content were among the main factors influencing structural traits, and higher structural values were recorded for *O. aurea* in heavy textured alkaline soils. Clay and silt particles provided better moisture conditions in the root microclimate zone by retaining long-term moisture. Various studies have found this fact; the heavy texture of the soil retains more moisture. Regarding the effect of soil texture on the yield of *Bromus tomentellus*, the highest and the lowest plant yields were related to loamy soils with a value of 63.18kg.ha^{-1} and sandy soils with a value of 3.71kg.ha^{-1}. It was concluded that the complementary function of loamy-textured soils was higher than other textures, with higher available water and silt content (soil fertilizer particles). Sandy soils had the least amount of plant production and available water deficiency due to the coarse texture. This was considered as one of the reasons for the decrease in production [34]. In every soil, the soil organic matter is increased when the soil texture gets finer, indicating the effect of silt and clay particles size on small and large organic matters and its long term preservation against the mineralization process [35]. Also, Johns [36] has reported that the plant-available water retention capacity differs according to the soil type, so that the heavy and deep soils have a large amount of water storage. The most important factor limiting the production of plants is the lack of soil moisture. Stoddart *et al.* [37] indicated that reducing the surface flows and increasing the moisture content of soil storage can be more efficient for increasing yield. Also, Abdollahi and Naderi [38] and Ghorbani *et al.* [39] noted that fine soil texture is introduced as one of the factors affecting the growth and expansion of plant production. Through investigating the relationship between qualitative traits of *Ferula ovina* and ecological conditions, Rahmati *et al.* [40] reported that the number of lower leaves, plant height and dry weight increased with increasing lime content. Also, by investigating the relationship between quality indices of *Astragalus prrowianus* and ecological conditions, it was reported that the habitats of *A. prrowianus* were distributed in high and sloping regions with metamorphic formations and soils having moderate cation exchange capacity, high amounts of lime and labile phosphorus and north-western slopes [41]. In addition, by investigating the correlation of the quality indices of *Fritillaria reuteri* with environmental factors, it was reported that fresh and dry weights of tulip in habitats having higher lime content were more than that of other habitats [42].

The results also indicated that structural traits were less affected by topographic characteristics (direction and elevation of ecological units). It can be due to the limited range of distribution of this species and the impossibility of study at a large spatial scale and topographic conditions with low diversity of the area. Some studies also emphasize the effect of climatic, topographic and soil factors on the productivity of rangeland ecosystems [43, 44]. On the other hand, several studies have acknowledged that on a small scale, as well as in arid and semi-arid regions, soil properties such as soil texture, organic carbon, and bulk density are the most important factors in tdetermination of plants distribution [45]. Regarding to the relationship between the density and canopy of *Astragalus gossypinus* with environmental factors, Fatahi *et al.* [46] reported that the density of *Astragalus* sp. in a local scale is strongly affected by soil factors (including sand, silt, acidity, and potassium), and topography factors play a more limited role. Other studies have also confirmed the above results [47, 48]. However, some studies indicated the impacts of changes in climatological factors on changes in leaf size [49]. The results of the present study regarding to the relationship between the biomass traits of *O. aurea* species and environmental factors showed that the organic matter content, moisture saturation percent, and porosity of the soil are factors affecting the biomass traits.

Accordingly, the *O. aurea* species in more fertile soils have more aerial biomass, and in soils with higher porosity and higher moisture saturation percent have more ground biomass and seed production. In contrast, soil parameters including gypsum content, gravel percentage, sand percentage, and bulk density also have a limiting role on total dry weight of leaflets and mean root dry weight. Generally, as a result, the soils with a high amount of organic matter produce more aerial biomass. Various studies have confirmed the relationship between biomass and nutrients availability, and they have stated that the changes in biomass depend mainly on soil nutrients rather than the other environmental gradients [50, 51]. On the other hand, the results of the present study indicated the positive correlation between soil fertility and aerial biomass, which is confirmed by the functional equilibrium theory [52] and resource allocation model [53]. This theory and model indicate that if the soil is rich in nutrients, then the plant saves a large amount of its biomass in the aerial parts, so that the light absorption process would be facilitated in competition with other species. Functional equilibrium theory emphasizes that the rate of photosynthesis is proportional to the rate of nutrient uptake and the plants achieve this balance by adjusting the relative size of shoot and root masses [52]. Zhao *et al.* [54] also stressed the important role of soil water content in biomass production. High soil moisture content causes the soil to retain more moisture during a rain event and while increasing its moisture content, improves plant growth. In addition, it is reported that by increasing organic matter in grasslands, the moisture content increased as well [55] and in spite of the clay content, by increasing the organic carbon content, the moisture retention capacity increased because of the gels resulted from decomposition of organic residues and microbial secretions. It is also reported that moisture content of the soil affects the available water for evaporation from soil surface and consequently affects the plant growth and production. Hence, acceptable information on soil moisture data is an important tool to predict the yield [56]. On the other hand, high soil porosity provides conditions for root penetration, increased root biomass and root morphology as well as reaching the water reservoir at lower depths of the soil [57].

Root morphology and biomass provide key information on the plant's ability to utilize soil sources [58]. Root length is a quantitative characteristic, considered as an indicator of the water and nutrients absorption by plants [43, 59]. Therefore, as a positive consequence, the process of increasing the nutrient storage in the underground part of the plant leads to increased plant regeneration and high-yielding seeds production for regeneration. It seems that, in high porosity soils, rangeland regeneration will be facilitated by natural regeneration (by increasing seed production). In the present study, it was determined that increasing bulk density and gypsum can reduce biomass production of *O. aurea* species. Schenk and Jackson [60] and Sheidai Karkaj *et al.* [45] reported the same results and indicated that the above parameters limited the rooting of plants and ultimately created an unfavorable environment for the plant establishment.

It is noteworthy that the natural distribution process of seeds by domestic animals, wildlife, and natural factors such as wind, water, and topography has a significant contribution in regulating the floristic richness and species composition of ecosystems [61, 62], which could be considered as a key factor in conservation biology [63, 64] and restoration management [65]. Therefore, due to the physical appearance of the seeds studied, in the case of natural distribution, light grazing can be considered as a practical option and contributes to the distribution of species, because the seeds stick to the animal body and can be transported along with the livestock to another location.

Similar to the results for structural characteristics, topographic factors have a smaller contribution than soil factors on biomass traits of the species studied. The slope percentage has little or no impact on any plant characteristics (structural and biomass traits). The results of the present study on the relationship between vegetation cover and soil factors indicated that soil factors had a major impact on plant distribution. Also, the vegetation cover contributed positively to the water and nutrients absorption, so that in the communities studied, the organic matter and texture had the most relationship with plant species.

Conclusion

Some environmental factors and management activities affect plant communities and their survival as well as plant morphology. Therefore, identifying the effects of soil and plant conservation and management as well as rangeland restoration, and forage production could play an important role to optimize harmful effects on plant communities. In the present study, using multivariate analysis, the most important environmental factors affecting structural traits and biomass were introduced. Therefore, the results of this study confirm the importance of applying multivariate analysis in achieving ecological requirements and geographical distribution of vegetation cover in different regions. The application of gradient analysis in this study showed that the RDA method was highly accurate to determine the plant indices.

The traits studied are divided into two groups of characteristics causing plant stability, regeneration and distribution, which together increase the plant's ability to maintain its community against environmental conditions. For example, the crown diameter, the collar diameter, the area and number of leaves, root length and plant density are among the characteristics determining the competitive strength of the species studied in the marl habitats.

The number of produced seed, its size, and the amount of aerial and ground biomass are also characteristics of regeneration, determining the ability of germination, competitive power and counteract plant degradation. What is certain is that the structural characteristics and especially the biomass traits will be greater when the study species are replanted in field soils (with low electrical conductivity, which salts available in the soil do not have an adverse effect on plant growth). Thus, in order to assess the plant's efficiency due to agronomic activities or rangeland improvement, the values of the traits studied should be considered as the basis or optimal limit. If the objective is production management and higher yields of the species in cropping or rangeland improvement operations, attention should be paid to this issue. If the values of structural features are acceptable, it could be concluded that the management operations of rangeland improvement or crop operations have been successful and the location of the improvement actions is desirable, or the cultivation practices in the agroecosystem are well suited to the needs of the plant. As shown in the ordination diagrams, the characteristics and traits of *O. aurea* did not respond significantly to the changes in soil salinity. This point indicates that the species is not sensitive to this salinity level. However, accurate statement requires further investigations and the application of different salinity treatments in the growth and establishment of this plant. Finally, it should be noted that in small scale planning, plant traits are mainly controlled by soil factors. Topographic factors are less important in explaining structural and biomass traits of plant species. Also, the contribution of environmental factors to the biomass traits is greater than the structural traits.

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References

1- Reich PB. The world-wide 'fast-slow'plant economics spectrum: A traits manifesto. J Ecol. 2014;102(2):275-301.

2- Weiher E, Van Der Werf A, Thompson K, Roderick M, Garnier E, Eriksson O. Challenging Theophrastus: A common core list of plant traits for functional ecology. J Veg Sci. 1999;10(5):609-20.

3- Poschlod P, Kleyer M, Jackel AK, Dannemann A, Tackenberg O. BIOPOP-a database of plant traits and internet application for nature conservation. Folia Geobotanica. 2003;38(3):263-71.

4- Cornelissen JH, Lavorel S, Garnier E, Díaz S, Buchmann N, Gurvich DE, et al. A handbook of protocols for standardised

and easy measurement of plant functional traits worldwide. Aust J Bot. 2003;51(4):335-80.
5- Grime JP. Plant strategies and vegetation processes and ecosystem properties. 2nd Edition. Hoboken: Wiley; 2001.
6- Tahmasebi P. Ordination (multivariate analysis in science and natural resources). Shahrekord: University of Shahrekord; 2015. [Persian]
7- Poorter H, Niklas KJ, Reich PB, Oleksyn J, Poot P, Mommer L. Biomass allocation to leaves, stems and roots: Meta-analyses of interspecific variation and environmental control. New Phytol. 2012;193(1):30-50.
8- Suding KN, Lavorel S, Chapin Iii FS, Cornelissen JH, DIAz S, Garnier E, et al. Scaling environmental change through the community-level: A trait-based response-and-effect framework for plants. Glob Chang Biol. 2008;14(5):1125-40.
9- Kleyer M, Dray S, Bello F, Lepš J, Pakeman RJ, Strauss B, et al. Assessing species and community functional responses to environmental gradients: Which multivariate methods?. J Veg Sci. 2012;23(5):805-21.
10- Violle C, Navas ML, Vile D, Kazakou E, Fortunel C, Hummel I, et al. Let the concept of trait be functional!. Oikos. 2007;116(5):882-92.
11- Lavorel S, Diaz S, Cornelissen JH, Garnier E, Harriso SP, McIntyr S, et al. Plant functional types: Are we getting any closer to the holy grail? In: Canadell JG, Pataki D, Pitelk L, editors. Terrestrial ecosystems in a changing world. Berlin: Springer; 2007. pp. 149-60.
12- Garnier E, Cortez J, Billès G, Navas ML, Roumet C, Debussche M, et al. Plant functional markers capture ecosystem properties during secondary succession. Ecology. 2004;85(9):2630-7.
13- Mokany K, Roxburgh SH. The importance of spatial scale for trait-abundance relations. Oikos. 2010;119(9):1504-14.
14- Peng Sh, Piao Sh, Shen Z, Ciais P, Sun Z, Chen Sh, et al. Precipitation amount, seasonality and frequency regulate carbon cycling of a semi-arid grassland ecosystem in Inner Mongolia, China: A modeling analysis. Agric For Meteorol. 2013;178-179:46-55.
15- Chang J, Wang Z, Li Y, Han G, Wang ZW. Relationship between aboveground net primary productivity and precipitation and air temperature of three plant communities in Inner Mongolia grassland. Acta Scientiarum Naturalium Universitatis NeiMongol. 2010;41:689-94.
16- Fan J, Zhong H, Harris W, Yu G, Wang Sh, Hu Z, et al. Carbon storage in the grasslands of China based on field measurements of above-and below-ground biomass. Clim Chang. 2008;86(3-4):375-96.
17- Brodribb TJ, Feild TS, Jordan GJ. Leaf maximum photosynthetic rate and venation are linked by hydraulics. Plant Physiol. 2007;144(4):1890-8.
18- Dunbar-Co S, Sporck MJ, Sack L. Leaf trait diversification and design in seven rare taxa of the Hawaiian Plantago radiation. Int J Plant Sci. 2009;170(1):61-75.
19- Cadotte MW, Carscadden K, Mirotchnick N. Beyond species: Functional diversity and the maintenance of ecological processes and services. J Appl Ecol. 2011;48(5):1079-87.
20- Lavorel S, Grigulis K, Lamarque P, Colace MP, Garden D, Girel J, et al. Using plant functional traits to understand the landscape distribution of multiple ecosystem services. J Ecol. 2011;99(1):135-47.
21- Dias AT, Krab EJ, Mariën J, Zimmer M, Cornelissen JH, Ellers J, et al. Traits underpinning desiccation resistance explain distribution patterns of terrestrial isopods. Oecologia. 2013;172(3):667-77.
22- Kahmen S, Poschlod P. Effects of grassland management on plant functional trait composition. Agric Ecosyst Environ. 2008;128(3):137-45.
23- Mládek J, Hejcman M, Hejduk S, Duchoslav M, Pavlů V. Community seasonal development enables late defoliation without loss of forage quality in semi-natural grasslands. Folia Geobotanica. 2011;46(1):17-34.
24- Verheyen K, Honnay O, Motzkin G, Hermy M, Foster DR. Response of forest plant species to land-use change: a life-history trait-based approach. J Ecol. 2003;91(4):563-77.
25- Aubin I, Gachet S, Messier Ch, Bouchard A. How resilient are northern hardwood forests to human disturbance? An evaluation using a plant functional group approach. Ecoscience. 2007;14(2):259-71.
26- Gondard H, Jauffret S, Aronson J, Lavorel S. Plant functional types: A promising tool for management and restoration of degraded lands. Appl Veg Sci. 2003;6(2):223-34.
27- Mitchell RJ, Auld MH, Le Duc MG, Robert MH. Ecosystem stability and resilience: A review of their relevance for the conservation management of lowland heaths. Perspect Plant Ecol Evol Syst. 2000;3(2):142-60.
28- Jalili A. Red data book of Iran: A preliminary survey of endemic, rare & endangered plant species in Iran. Tehran: Research Institute of Forests and Rangelands; 1999. [French]
29- Ranjbar M, Amirabadizadeh H, Karamian R, Ghahremani MA. Notes on Onobrychis sect. Heliobrychis (Fabaceae) in Iran. Willdenowia. 2004;34(1):187-90.
30- Motamedi J, Abdolslizadeh Z, Sheidaei Karkaj E. Field and laboratory methods for grassland and animal production research. Urmia: University of Urmia Press; 2016. [Persian]
31- Carter MR, Gregorich EG. Soil sampling and methods of analysis. 2nd Edition. Abingdon: Taylor & Francis; 2007.
32- Jongman EJ. Data analysis in community and landscape ecology. Cambridge: University of Cambridge; 1995.
33- Elias Azar K. Public and private soil science. Urmia: University of Urmia; 1990. [Persian]
34- Ajami M, Khormali F, Ayobi, SH. Changes in some soil quality parameters due to land use change in different locations of sloping lands in the east of Golestan Province. Iran J Soil Water Res. 2008;39(1):15-30. [Persian]
35- Tisdall JM, Oades J. Organic matter and water-stable aggregates in soils. J Soil Sci. 1982;33(2):141-63.
36- Jones CS. Does shade prolong juvenile development? A morphological analysis of leaf shape changes in Cucurbit a argyrosperma Subsp. Sororia (Cucurbitaceae). Am J Bot. 1995;82(3):346-59.
37- Stoddart L, Smith A, Box D, Thadis W. Range management. New York: McGraw-Hill Book Company; 1975.
38- Abdollahi J, Naderi H. Soil and topographical variation influencing the growing factors of Artemisia sieberi in steppic rangeland, Nodoushan-Yazd. PAJOUHESH-VA-SAZANDEGI. 2013;25(4):52-62. [Persian]
39- Ghorbani A, Moameri M, Dadjou F, Seyedi Kaleybar SA, Pournemati A, Asghari S. Determinization of environmental factors effects on plants production in QezelOzan-Kosar rangelands, Ardabil Province factors effect on rangelands production. Ecopersia. 2020;8(1):47-56.

40- Rahmati Z, Tarkesh Esfahani M, Pourmanafi S, Vahabi MR. Potential habitat modelling of Ferula ovina using artificial neural network in Fereydunshahr region, Isfahan Province. Iran J Appl Ecol. 2015;4(11):41-53. [Persian]
41- Vahabi MR, Basiri M, Moghadam MR, Masoumi AA. Determination of the most effective habitat indices for evaluation of tragacanth sites in Isfahan Province. Iran J Nat Resur. 2007;59(4):1013-29. [Persian]
42- Najafi M, Vahabi MR, Tarkesh Esfahani M. The application modeling potential habitat in habitat protection Fritillaria (Fritillaria imperialis). J Plant Ecosyst Conserv. 2016;3(7):113-28. [Persian]
43- Sun J, Cheng G, Li W, Sha Y, Yang Y. On the variation of NDVI with the principal climatic elements in the Tibetan Plateau. Remote Sens. 2013;5(4):1894-911.
44- Javidfar A, Rouhi-Moghaddam E, Ebrahimi M. Some ecological conditions of amygdalus scoparia Spach in Nehbandan, Eastern Iran. Ecopersia. 2017;5(1):1655-67.
45- Sheidai Karkaj E, Akbarlou M, Jafari I, Shakhsi Khodabakhsh E. Land use management response on carbon sequestration and soil properties (case study: Kalpoush plain, Golestan province). Int J Agric. 2013;3(2):299-304.
46- Fattahi B, Aghabeigi Amin S, Ilderimi AR, Maleki M, Hasani J, Sabetpoor T. Investigation of some environmental factors affecting Astragalus gossypinus in mountain ranges of Zagros (Case study: Galebar rangelands in Hamadan Province). J Rangel Sci. 2009;3(2):203-16. [Persian]
47- Moradi HR, Tahmasebi A, Erfanzadeh R. Study of relation among vegetation, soil and geomorphologic factors in Kasilian watershed using GIS. J Agric Sci Nat Resour. 2004;2(2):38-53. [Persian]
48- Ahmadi A, Zahedi Amiri G, Mahmoodi Sh, Moghiseh E. Soil-vegetation relationships in saliferous and gypsiferous soils in winter rangelands (Eshtehard). J Nat Res. 2007;60(3):1049-58. [Persian]
49- Royer DL, McElwain JC, Adams JM, Wilf P. Sensitivity of leaf size and shape to climate within Acer rubrum and Quercus kelloggii. New Phytol. 2008;179(3):808-17.
50- Poorter H, Nagel O. The role of biomass allocation in the growth response of plants to different levels of light, CO_2, nutrients and water: A quantitative review. Funct Plant Biol. 2000;27(12):1191.
51- Dianati Tilaki GA, Naderi Nasrabad H, Abdollahi J. Investigation of relationship between vegetation, topography and some soil physico-chemical characteristics in Nodoushan rangelands of Yazd Province (Iran). Ecopersia. 2011;1(2):147-56.
52- Brouwer R. Nutritive influences on the distribution of dry matter in the plant. Neth J Agric Sci. 1962;10(5):399-408.
53- Tilman D. Plant strategies and the dynamics and structure of plant communities. Princeton: University of Princeton; 1988.
54- Zhao Ch, Feng Z, Chen G. Soil water balance simulation of alfalfa (Medicago sativa L.) in the semiarid Chinese Loess Plateau. Agric Water Manag. 2004;69(2):101-14.
55- Emerson WW. Water-retention, organic-C and soil texture. Soil Res. 1995;33(2):241-51.
56- Wen J, Su, B. A method for estimating relative soil moisture with ESA wind scatterometer data. Geophys Res Lett. 2003;30(7):50-4.
57- Teague WR, Dowhower SL, Baker SA, Haile N, DeLaune PB, Conover DM. Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie. Agric Ecosyst Environ. 2011;141(3-4):310-22.
58- Berntson GM. Topological scaling and plant root system architecture: Developmental and functional hierarchies. New Phytol. 1997;135(4):621-34.
59- Ryser P, Eek L. Consequences of phenotypic plasticity vs. interspecific differences in leaf and root traits for acquisition of aboveground and belowground resources. Am J Bot. 2000;87(3):402-11.
60- Schenk HJ, Jackson RB. Mapping the global distribution of deep roots in relation to climate and soil characteristics. Geoderma. 2005;126(1-2):129-40.
61- Pärtel M, Zobel M, Zobel K, Van Der Maarel E. The species pool and its relation to species richness: Evidence from Estonian plant communities. Oikos. 1996;75(1):111-7.
62- Cain ML, Milligan BG, Strand AE. Long-distance seed dispersal in plant populations. Am J Bot. 2000;87(9):1217-27.
63- Trakhtenbrot A, Nathan R, Perry G, Richardson DM. The importance of long-distance dispersal in biodiversity conservation. Divers Distrib. 2005;11(2):173-81.
64- Haddad NM, Bowne DR, Cunningham A, Danielson BJ, Levey DJ, Sargent S, et al. Corridor use by diverse taxa. Ecology. 2003;84(3):609-15.
65- Palmer MA, Ambrose RF, Poff NL. Ecological theory and community restoration ecology. Restor Ecol. 1997;5(4):291-300.