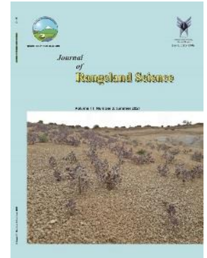

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Research and Full Length Article:

Investigating the Soil Seed Bank and Its Relation with the Aboveground Vegetation along an Elevation Gradient in Kashan, Iran

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Abstract. A part of plant species composition in natural ecosystems is live seeds that are hidden in the soil and known as soil seed bank. Detecting this species resource has a key role in protecting and restoring the vegetation. The present study aims to investigate the soil seed bank and its relationship with the aboveground vegetation along an elevation gradient in Kashan, Iran. For sampling from the soil seed bank, three transects with 200 m length were established in June 2017. The soil samples were taken from two depths ranging 0-5 and 5-10 cm out of 1 m^2 plots with 20 m intervals. The soil samples were transferred to the greenhouse. Moreover, the cover percent of plant species within each plot was recorded in the vegetation season in spring 2018. The features of soil seed bank in different elevations were compared by F-test. The results of one-way analysis of variance showed that the effect of altitude from sea level on the Shannon's diversity ($p<0.05$) and soil depth on the density, Menhinik and Margalef richness was significant ($p<0.05$ and $p<0.01$). The higher value of Shannon diversity in upper altitude (2800-3000 m above sea level) and higher value of Dnensity, Margalof and Menhinik in upper soil depth (0-5 cm) was obtained. The results of greenhouse experiments showed that most of the germinated seeds belong to annual grass species. While the surface cover of most species is related to perennial plants. The highest coverage of *Artemisia aucheri* was from 2600-2800 m a.s.l. and the lowest percentage of cover belonged to *Alyssum linifolium* in the elevations of 2800-3000 m a.s.l.Therefore, it can be concluded that in the study area, seeds of perennial plants do not have a readiness for germination in soil depths or they should remain in soil for a long time and should be described as stable seed banks.

Key words: Elevation, Germination, Density, Diversity, Soil seed bank

Introduction

Rangelands are regarded among the natural and dynamic ecosystems on earth. For the optimum management and utilization, there should be a clear understanding of their components and their response to various interventions and changes (Sharifi and Imani, 2006).

Seed is an important part of the regeneration process in plant communities and a source of diversity for genetic differentiation and evolution of plants in various ecosystems (Kemp, 1989).

Soil seed bank plays an important role in the process of succession and conservation of communities. Major and Pyott (1966) stated that the seed bank is part of the flora of an area, which can be used to determine the community although this is not easily evident. Soil seed banks play an important role in the dynamics and description of surface cover of the earth, although this role varies from one ecosystem to another (Wolters and Bakker, 2002).

So far, several studies have been carried out on soil seed banks in various types of coatings on the planet (from tundra to equator) to identify the role of soil seed bank in restoring the affected areas after possible degradation. In this regard, the common goal in most soil seed bank studies is to compare the vegetation composition of soil seed banks with the combination of aboveground vegetation and the identification of the buried seed soil capacity for a site in restoring the biodiversity of its habitats. In fact, the similarity of the cover and the soil seed bank helps us to estimate another one by evaluating the first one (Aghababaei Taleghanki *et al.*, 2014).

However, since the seed bank information and the aboveground vegetation on the degraded sites can be used to guide revival activities in the same ecosystem, it is very important to know them and to investigate the relationship between these two factors (Oldeland *et al.*, 2010).

Thompson and Grime (1979) believe that although the seed composition of the seed bank and the aboveground vegetation of each habitat are related together, it is possible that some herbaceous species may be only present in one part and in another part, the degree of similarity of the seed bank in the soil with its corresponding vegetation cover has been low in most natural habitats.

Characteristics of soil seed bank at the level of a habitat such as aboveground vegetation characteristics are under the impact of environmental factors including soil hysico-chemical properties, physiographic characteristics (elevation, slope and slope direction that control the temperature and humidity of the environment) and its biological factors (seed population and pathogens) so that the plant composition and the size of soil seed bank in different plant communities of a habitat as well as their abundance with respect to the abovground vegetation are different (Bossuyt and Hermy, 2008).

Vegetation substitution stages, whether in the early stages or late ones of the sequence, is another factor that affects the soil seed bank characteristics (density and similarity to aboveground vegetation). If the composition of plant communities changes over time, the seeds of earlier stages can be found in the soil. In other words, with the course of the plant sequence from the initial stages to the peak, the seeds of the plants are buried in the soil and in conditions when the vegetation is in the finishing stages of the sequence, the seeds of the earlier or even elementary stages can be observed in the seed bank (Tahmasebi, 2013).

The first basic step in the formation of a stable seed bank is seed burial. The seed components as well as their number on the soil surface may be damaged/influenced by one of the following two conditions involving germination and hunting, but when the seed is buried, the probability of occurrence of both of these conditions decreases. Seed hunting is reduced due to the fact that most seed hunters are inactive in the soil (Price and Joyner, 1997).

Seed banks are sampled by digging the ground in the middle of different depths and spreading the soil in trays in conditions suitable for germination and seedling counting. In a small number of studies, seeds are extracted from the soil and then, counted. But this method has few disadvantages. Extracting seeds from organic soil is not easy, and the tiny seeds are easily lost and difficult to detect. The best solution is to reduce the volume of the soil by sifting and then, the remaining seeds can be germinated in the reduced volume of soil. The advantage of this action is to reduce the required space and accelerate the germination (Ter Heerdt *et al.*, 1996).

Also, Thompson (1992) stated that soil seed bank not only guarantees the establishment of plant populations in the event of adverse conditions, but also may be responsible for the emergence of new plant genotypes that are critical to the survival of plant populations in that area.

On the other hand, Identification of soil seed storage (seed bank) has been considered as a key to solve many problems of vegetation management, conservation of rare species and ecosystem diversity where the seed bank can potentially be used in vegetation repair and modification programs (Skoglund, 1992). Due to the importance of soil seed bank in repairing the damaged vegetation and preserving the genetic resources, studying various related topics in recent years has become very important (Erfanzadeh *et al.*, 2009).

Different elevation classes of seed bank indicate the importance of height in species isolation. Among the dominant species in the area, some species tend to higher elevations and some have tendency toward lower elevations and appear in the soil regardless of surface cover (Hegazy *et al.*, 2009).

The composition of seed bank species is more diverse at lower elevations and more uniform at higher elevations (Hegazy *et al.*, 2009), which may be due to the effect of gravity on seed movement. The study of seed bank is important not only as the most important source of seed supply in order to establish vegetation communities after the destruction of their daily vegetation (Hayatt, 1999), but also as a reliable, feature that indicates the risk of removing any plant from the floristic list of an area in the event of degradation.

The study of soil seed bank is a key step in some aspects of practical management in terms of conservation of natural resources and effective conservation of rare species and various ecosystems, especially after disruption (Bertiller and Aloia, 1997). The presence of many defective and invasive species after regeneration can be due to their rich seed bank in the soil, which needs to be identified before regeneration (Ghorbani *et al.*, 2008). Awareness of the diversity and richness of soil seed bank species in rangeland ecosystems is a criterion that can determine the potential for restoration of degraded vegetation (Bekker *et al.*, 1997). For this purpose, it is very important to evaluate the similarity of species composition between existing vegetation and plant species reserves in the soil (Hosseini and Shahmoradi, 2011; Abarsaji, 2000). Both vegetation information and soil seed bank can be used to protect and regenerate plant species. Prior to the implementation of management programs and rehabilitation projects, it is necessary to consider the similarity of the composition of vegetation species and soil seed bank.

The aim of this study is to investigate the effect of changes in elevation from sea level on soil seed bank diversity and density at different soil layers in addition to comparing similarity between the soil seed bank and aboveground vegetation of Ghohrud rangelands in Kashan, Iran.

Materials and Methods

Study area

In terms of country divisions, Ghohrud village is located in Ghamsar and Ghohrud area, Kashan region, Isfahan province, Iran (Fig. 1). This area is about 142.33 km^2. Its elevation is 950 m above sea level. In terms of cluster classification, the region is located on the central plateau and has arid climate (Jokar *et al.*, 2013).

Ghohrud village is located at 46 km south of Kashan in the vicinity of Ghamsar. With the riverside adjacent to the village, the southern plains and the northern plain leading to Kashan are quite distinct (Fathi and Mokhtarpour, 2014).

The mean annual precipitation is 200 mm, the warmest month is August with a maximum temperature of +30°C and the coldest months are February and March with minimum temperature of - 20°C. The area is considered as a bird rangeland. The dominant herd of this region is Gon, Steppe, Frafion and Conger (Archives of the Natural Resources Office). The lowest and highest elevation of the Suldar rangeland is about 2350 and 3300 m, respectively. The difference between these two points is 950 m.

Field Sampling Method

Soil sampling was performed in mid to late fall (after dispersing the seeds of plants) by a systematic randomized method along three transects with a length of 200 m (two transects parallel to the slopes and one transect perpendicular to gradient) in different elevations. Four elevation classes were determined as 2400 - 2600, 2600 - 2800 and 2800 – 3000 m a.s.l.. In each transect, 10 plots (1m²) were established at intervals of 20 m.

Soil samples were taken with a diameter of 2.5 cm and from two depths of 0−5 cm and 5−10 cm, with 10 replications. The location of the plots was spotted during sampling and their location was determined by GPS. Then, samples of each separate depth were mixed into nylon bags and transferred to the greenhouse.

Vegetation sampling was done in early June 2017 when growth stage was completed before the beginning of the grazing season, when most of the plant species are expected to be present at the surface of the region and reach full growth in the same plots marked. It was done in all three levels of elevation. Then, the characteristics of the coating were measured and recorded. Data collected for crown cover percentage, bare soil, litter, stone and pebble as well as plant density. A total of 90 plots from the whole area were sampled.

Greenhouse experiment

In order to determine the composition of soil seed bank species. Soil samples were disposed in disposable containers with holes previously drilled under them on a bed of sterile sand (1 cm deep) to a height of 1 cm. First, rocks and pebbles, plant root residues, rhizomes and bulbs were isolated from soil samples. Containers containing soil samples were placed on the greenhouse tables. The floor of the table was covered with nylon and a cotton cover to help retain moisture. Watering the dishes daily was done through the bottom of the table by pouring water on a cotton cloth. A number of dishes were filled with sterile sand and placed on tables as controls. Samples were kept in the greenhouse for 3 to 9 months for germination and seed bank identification. Seedlings were identified and recorded at different time periods and then gently separated to allow the environment for other seeds to grow. If seedling was not identified, the plants were moved to a larger container to be identified after sufficient growth.

Data analysis

The emerged seedlings from two depths of soils (0−5 and 5−10 cm) were counted. To compare the soil seed bank characteristics such as density, richness, species diversity and similarity (Hosseini Kahnouj et al., 2015) and relationships between the soil seed bank with ground cover in different elevations and depths, the F test was used. The results were analyzed using SPSS software and charts were executed by Excel software.

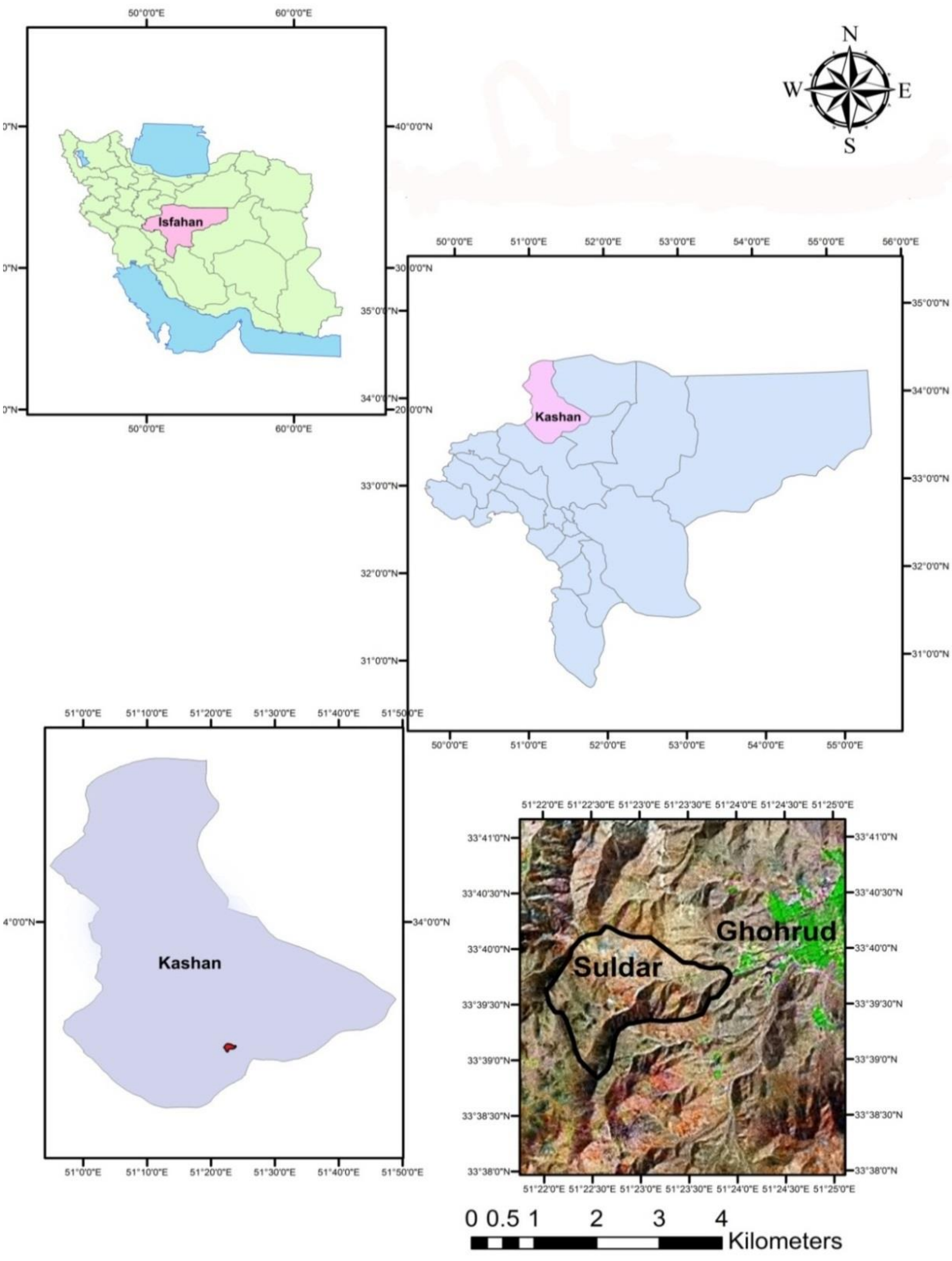


Fig 1. Map of the position of Suldar rangeland in Ghohrud village, Kashan County in Iran's national divisions

Results

Greenhouse experiment

The results of greenhouse experiments showed that most of the germinated seeds belong to annual grass species. While the suface cover of most species is related to perennial plants. The highest coverage of *Artemisia aucheri* was from 2600-2800 m a.s.l. and the lowest percentage of cover belonged to *Alyssum linifolium* in the elevations of 2800-3000 m a.s.l. The results on the aboveground vegetation and greenhouse species showed that there were 23 species in the soil seed bank and 13 species in the above-ground vegetation. Also, four species between the soil seed bank and cover were common (Table 1).

In this study, 40 species belonging to 16 families in the area were identified. Asteraceae with 7 species, and Poaceae with 5 species had the highest shares in the species composition of the studied area (Table 1 and Fig. 2).

Table 1. List of aboveground vegetation and seed banks plants, and the percentage of plant cover Aboveground plant

Species	Family	Altitude m (Plant cover %)		
		2400-2600	2600-2800	2800-3000
Chenopodium murale (L.) S. Fuentes, Uotil & Borsch**	Amaranthaceae			
Chenopodium novopokrovskyanum (Aellen) Uotila **	Amaranthaceae			
Kochia stellaris Moq.**	Amaranthaceae			
Chenopodium album L.**	Amaranthaceae			
Eryngium thyrsoideum Boiss.	Apiaceae	0.57		3.46
Artemisia aucheri Boiss. *	Asteraceae		8.83	
Achillea santolinoides subsp. *wilhelmsii* (K.Koch) Greuter	Asteraceae		0.67	
Carthamus oxyacantha M.Bieb	Asteraceae	0.10		0.40
Echinops leiopolyceras Bornm.	Asteraceae		0.07	0.07
Gundelia tournefortii L.	Asteraceae	1.20		
Lactuca orientalis Boiss.	Asteraceae	2.60	0.53	0.50
Senecio glaucus L.**	Asteraceae			
Anchusa azurea Mill. **	Boraginaceae			
Heliotropium supinum L.**	Boraginaceae			
Rochelia persica Bunge ex Boiss.**	Boraginaceae			
Alyssum linifolium Stephan ex Willd.*	Brassicaceae			0.03
Conringia orientalis (L.) Dumort. **	Brassicaceae			
Malcolmia sp. **	Brassicaceae			
Holosteum umbellatum L.**	Caryophyllaceae			
Minuartia meyeri Bornm.**	Caryophyllaceae			
Minuartiella acuminata (Turrill) Dillenb. & Kadereit **	Caryophyllaceae			
Euphorbia polycaulis Boiss. & Hohen.	Euphorbiaceae		0.10	0.16
Euphorbia sororia Schrenk**	Euphorbiaceae			
Astragalus lycioides Boiss.	Fabaceae	2.63	1.83	3.467
Astracantha gossypina (Fisch.) Podlech	Fabaceae		1.40	
Geranium kotschyi Boiss.**	Geraniaceae			
Geranium robertianum L.**	Geraniaceae			
Stachys inflata Benth.	Lamiaceae	0.27	0.07	
Phlomis olivieri Benth.	Lamiaceae		0.33	
Ziziphora tenuior L.**	Lamiaceae			
Veronica intercedens Bornm.**	Plantaginaceae			
Bromus tomentellus Boiss.	Poaceae	0.53		3.56
Stipa barbata Desf.	Poaceae	0.50	0.23	0.37
Bromus tectorum L.*	Poaceae	0.26		2.87
Eremopyrum orientale (L.) Jaub. & Spach**	Poaceae			
Setaria viridis (L.) P.Beauv.**	Poaceae			
Polygonum sp. **	Polygonaceae			
Ceratocephalus falcatus (L.) Pers.**	Ranunculaceae			
Ranunculus sp. **	Ranunculaceae			
Crucianella gilanica subsp. *glauca* (A.Rich. ex DC.) Ehrend *	Rubiaceae		0.13	

*Common plant species between aboveground vegetation and soil seed bank. **Plant species of soil seed bank

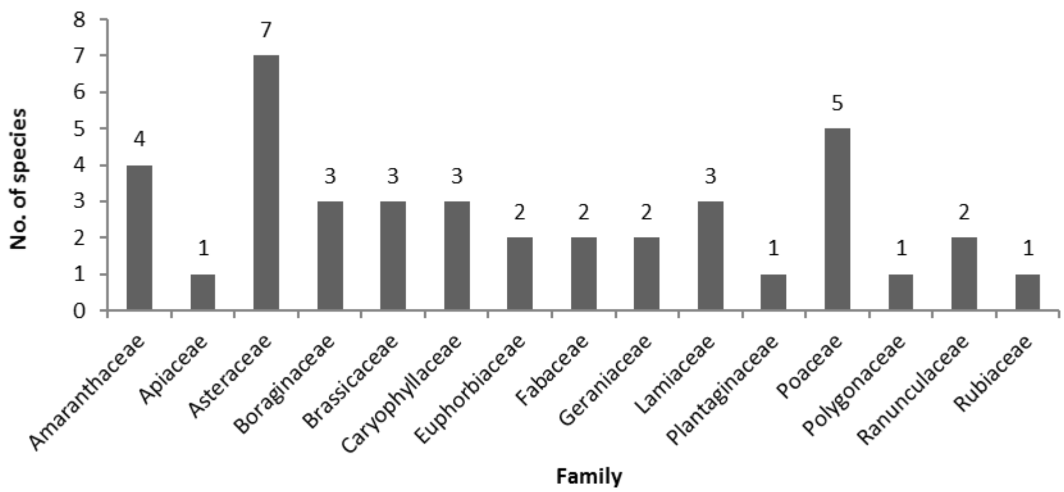


Fig 2. Frequency of species families in the study area

Vegetative Form, Biological Form and Geographic Distribution

The results of the biological form (Table 2) showed that the therophytes (Th) with 21 species (52%) were the most abundant biological form among these studied species and the hemicryptophytes were in the next ranks with 14 species (35%), Geophytes with 1 species (3%) (the lowest observed vegetative form) and cryptophytes (Cr) and chamaephytes (Ch) with 2 species (5%) (Fig. 3).

On the other hand, the elements of Irano-Turani region with 25 species of existing species accounted for 62% and the elements belonging to several regions with 4 species (10%) were in the next category (Fig. 4).

Table 2. Results of the biological form and geographic distribution of plant species in the study area

Species	Abbr.	Biological form	Geographical distribution
Achillea santolinoides subsp. *wilhelmsii*	He	Hemicryptophyte	IT, ES, SS
Alyssum linifolium	Th	Therophytes	IT, M
Anchusa azurea	Th	Therophytes	IT
Astracantha gossypina	Ch	Camphatt	IT
Astragalus lycioides	Ch	Camphatt	IT
Bromus tectorum	Th	Therophytes	Cosm
Bromus tomentellus	He	Hemicryptophyte	IT
Carthamus oxyacantha	He	Hemicryptophyte	IT, Cosm
Ceratocephalus falcatus	Th	Therophytes	IT, ES, M
Chenopodium album	Th	Therophytes	Cosm
Chenopodium murale	Th	Therophytes	Pl
Chenopodium novopokrovskyanum	Th	Therophytes	IT, H
Conringia orientalis	Th	Therophytes	IT
Crucianella gilanica subsp. *glauca*	He	Hemicryptophyte	IT
Echinops leiopolyceras	Th	Therophytes	IT
Eremopyrum orientale	Th	Therophytes	IT
Eryngium thyrsoideum	He	Hemicryptophyte	IT
Euphorbia sororia	He	Hemicryptophyte	IT
Euphorbia polycaulis	He	Hemicryptophyte	IT
Geranium kotschyi	Cr	Cryptophytes	IT
Geranium robertianum	Th	Therophytes	IT-ES
Gundelia tournefortii	He	Hemicryptophyte	IT
Heliotropium supinum	Th	Therophytes	Pl
Holosteum umbellatum	Th	Therophytes	Cosm
Kochia stellaris	Th	Therophytes	IT

Species	Abbr.	Biological form	Geographical distribution
Lactuca orientalis	He	Hemicryptophyte	Pl
Malcolmia sp.	Th	Therophytes	IT
Minuartia meyeri	Th	Therophytes	IT
Minuartiella acuminata	Th	Therophytes	IT
Phlomis olivieri	He	Hemicryptophyte	IT
Polygonum sp.	He	Hemicryptophyte	IT
Ranunculus sp.	Ge	Geophytes	ES
Rochelia persica	He	Hemicryptophyte	IT
Senecio glaucus	Th	Therophytes	IT, ES
Seriphidium aucheri	Cr	Cryptophytes	IT
Setaria viridis	Th	Therophytes	Pl
Stachys inflata	He	Hemicryptophyte	IT
Stipa barbata	He	Hemicryptophyte	IT
Veronica intercedens	Th	Therophytes	IT
Ziziphora tenuior	Th	Therophytes	IT

IT: Iran Turanian, ES: Europe, M: Mediterranean, SS: Desert, PL: Multi-unit, Cosm: Cosmopolitan, Hyr: Hyrcanian

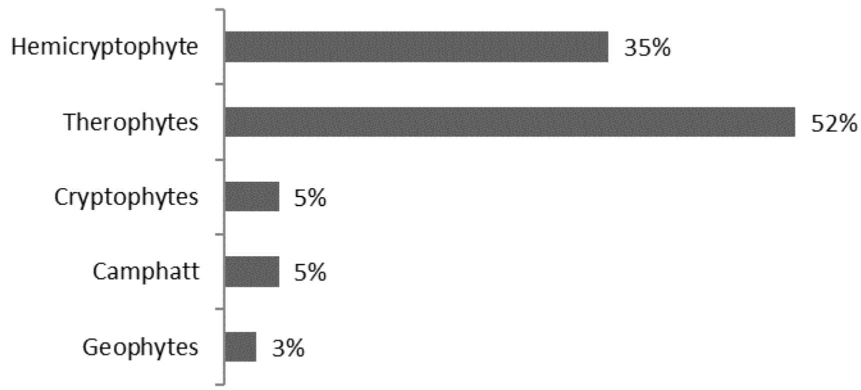


Fig 3.Percentage of biological forms of plant species in Suldar rangelands

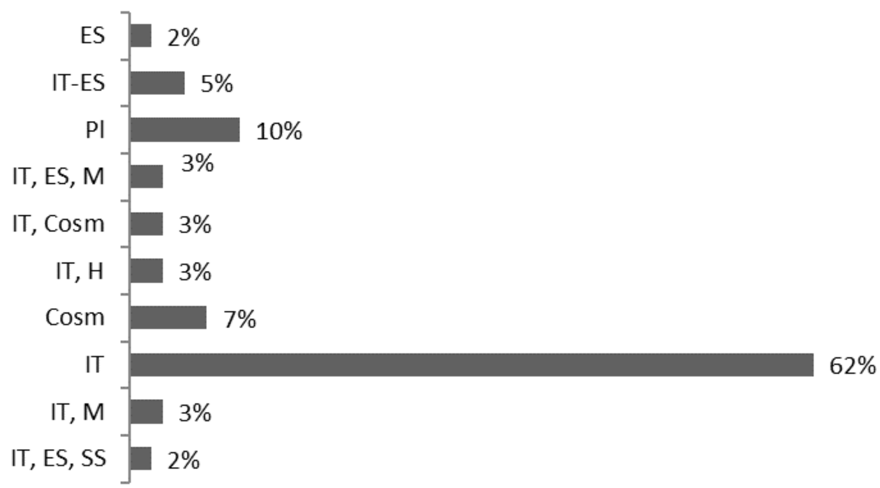


Fig 4. Frequency distribution of geographical regions and vegetative regions
IT: Iran Turanian, ES: Europe, M: Mediterranean, SS: Desert, PL: Multi-unit, Cosm: Cosmopolitan, Hyr: Hyrcanian

Plant Density

A total of 17 species were recorded, which included a large percentage of the species such as *Bromus tectorum*, *B. tomentellus* and *Astragalus lycioides*. Of course, there were some shrubs or shrub species in the coating, but no germination and emergence in the greenhouse were significant. The highest density was on the ground at elevation, of 2600-2800 m a.s.l. and was related to the species *B. tomentellus* and *Artemisia aucheri* at depth of 0-5 cm (Table 3).

The soil samples included a limited number of seeds, both in terms of density and diversity. The highest seed density was at a elevation of 2600-2800 m a.s.l. and at a depth of 0-5 cm. The most germinated seeds belonged to *Artemisia aucheri*, *Malcolmia sp*., in particular at elevation of 2600-2800 m a.s.l. and at depth of 0-5 cm. The seed bank density at elevation of 2600-2800 m a.s.l. was far higher than other elevations. Also, soil seed bank density at all elevations at depth of 0-5 cm was far more than the depth of 5-10 cm (Table 4).

Table 3. Average plant density of the ground on the soli (m^{-2})

Species	Altitude / plant density (m^{-2})		
	2400-2600 m	2600-2800	2800-3000
Achillea santolinoides subsp. *wilhelmsii*		0.294	
Alyssum linifolium			0.294
Artemisia aucheri Boiss.		3.882	
Astracantha gossypina		0.411	
Astragalus lycioides	0.882	1.706	0.941
Bromus tectorum	0.470		3.234
Bromus tomentellus	0.941		3.529
Carthamus oxyacantha	0.353		0.529
Crucianella gilanica subsp. *glauca*		0.176	
Echinops leiopolyceras		0.059	0.059
Eryngium thyrsoideum	0.765		1.294
Euphorbia polycaulis		0.176	0.059
Gundelia tournefortii	0.412		
Lactuca orientalis	0.471	0.470	0.470
Phlomis olivieri		1.000	
Stachys inflata	0.118	0.118	
Stipa barbata	0.353	0.235	0.294

Table 4. Average plant density of soil seed bank and density on the ground Seed density m^{-2} of species in soil

Species	Altitude					
	2400-2600 m		2600-2800 m		2800-3000 m	
	(Soil Depth cm)					
	0-5	5-10	0-5	5-10	0-5	5-10
Achillea santolinoides subsp. *wilhelmsii*	0.03					
Alyssum linifolium	0.03				0.03	0.07
Anchusa azurea		0.03				
Seriphidium aucheri			1.70	0.20		
Bromus tectorum	0.70	0.03			0.60	0.10
Chenopodium novopokrovskyanum					0.03	
Ceratocephalus falcatus	0.07				0.20	0.03
Chenopodium album	0.10					
Chenopodium murale						0.03
Conringia orientalis .			0.10		0.10	
Crucianella gilanica subsp. *glauca*				0.03		
Eremopyrum orientale					0.20	
Euphorbia sororia	0.07					
Geranium kotschyi					0.03	
Geranium robertianum					0.07	

Heliotropium supinum			0.03			
Holosteum umbellatum	0.07					0.03
Kochia stellaris			0.03			
Lactuca orientalis						
Malcolmia sp.	0.07		3.40	0.20	0.30	0.03
Minuartiella acuminata				0.07		
Minuartia meyeri			0.03			
Ranunculus sp.					0.03	
Rochelia persica					0.10	0.07
Senecio glaucus					0.03	
Setaria viridis					0.07	
Veronica intercedens	0.03		0.90	0.10	0.20	0.10
Ziziphora tenuior		0.03				

Analysis of variance and means of diversity indices

The results of analysis of variance showed that the effect of elevation was significant for Shannon diversity. It was also found that the effect of soil depth was significant for Density, Margalof and Menhinik indices (p<0.05) (Table 5).

The results of mean comparison showed that higher values of species richness (Dnensity, Margalof and Menhinik) were obtained in upper depth (0-5 cm) (Table 6).

The higher value of Shannon diversity was observed in upper altitude (2800-3000 m above sea level). A similar trend was obtained for plant species uniformity. The higher values of species Density, Margalof, Menhinik) and MacArthur's Diversity were obtained in middle altitude (2600-2800m above sea level) (Table 7).

The means of elevations by soil depth interaction effects is presented in Fig 5. The results obtained from the mean comparison of species richness (Dnensity, Margalof and Menhinik) were obtained in upper soil depth (0-5 cm) (Fig 5). The higher values of Uniformity and Shannon diversity were observed in upper altitude (2800-3000 m above sea level) coupled with in upper soil depth (0-5 cm). In contrast, the higher values of Similarity index was observed in lower altitude (2400-2600 m above sea level) coupled with in upper soil depth (0-5 cm) (Fig 5).

Table 5. Analysis of variance of elevations and soil depth effects on density, diversity, similarity, richness and uniformity.

Diversity indices	Altitude			Soil depth		
	DF	F value	sig	DF	F value	sig
Density	2	0.561	0.621	1	4.444*	0.063
Margalof	2	0.789	0.530	1	3.193*	0.080
Menhinik	2	0.679	0.571	1	5.366**	0.011
Shannon's diversity	2	4.814*	0.060	1	0.419	0.553
Similarity	2	2.393	0.172	1	1.342	0.330
Simpson's diversity	2	0.890	0.497	1	2.181	0.214
Uniformity	2	1.241	0.354	1	1.804	0.250
MacArthur's Diversity Index	2	0.807	0.524	1	2.268	0.207

*, **=significant at 0.05 and 0.01 probability level, respectively

Table 6. Means of density, diversity, similarity, richness and uniformity in three two soil depths

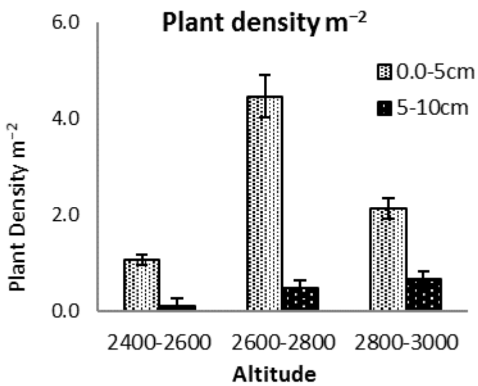
Soil Depth	Density	Margalof	Menhinik	Shannon diversity	Similarity	Simpson's variety	Uniformity	MacArthur's Diversity
0-5 cm	2.555 a	16.849 a	9.043 a	2.015 a	0.787 a	0.658 a	12.757 a	49.976 a
5-10 cm	0.410 b	3.073 b	3.624 b	1.523 a	0.259 a	0.490 a	2.950 b	7.143 b

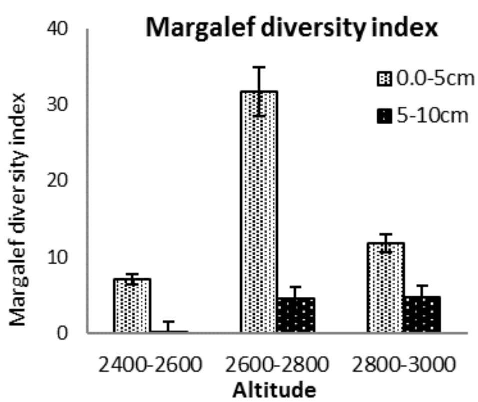
Means followed by the same letter are not significantly different

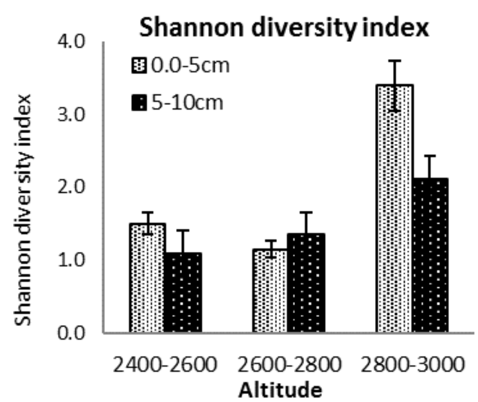
Table 7. Means of density, diversity, similarity, richness and uniformity in three elevations

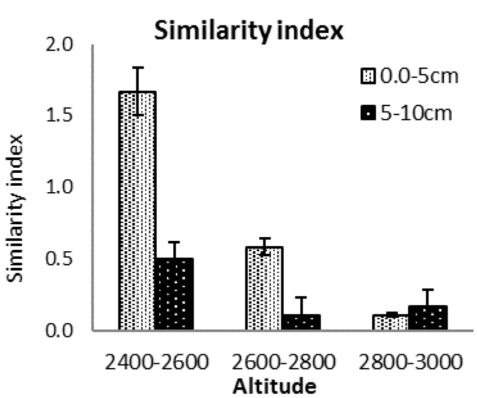
Altitude	Density	Margalof	Menhinik	Shannon diversity	Similarity	Simpson's variety	Uniformity	MacArthur's Diversity
2400-2600	0.583 b	3.546 b	3.780 b	1.301 b	1.083 a	0.650 a	5.275 b	11.200 b
2600-2800	2.466 a	18.099 a	8.659 a	1.250 b	0.347 b	0.453 a	2.215 b	58.193 a
2800-3000	1.399 ab	8.225 b	6.562 ab	2.757 a	0.139 b	0.620 a	16.070 a	16.285 b

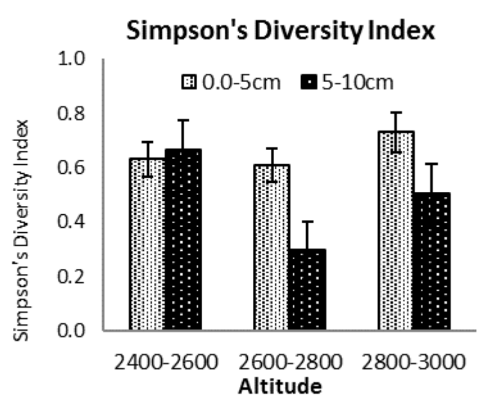
Means followed by the same letter are not significantly different











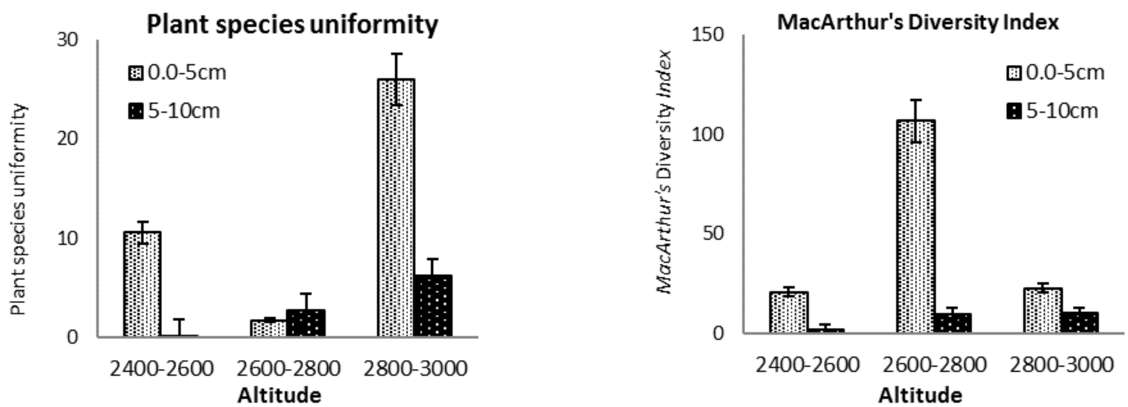


Fig 5. Means of elevations by soil depth interaction effects for diversity, similarity, richness and uniformity indices

Annual and perennial plant composition

Means comparing of the annual and perennial plant cover composition in three elevations are presented in Fig 6. For the annual species the higher cover composition with values of 20% was obtained in upper elevation 2800-3000 m. For perennial specie, the cover composition with values of 95, 94 and 77% were obtained for 2400-2600, 2600-2800 and 2800-3000 m above sea levels, respectively (Fig 6).

The higher annual soil seed composition with average values of 90 and 92% were obtained at 0-5 cm soil depth (in elevation of 2400-2600 m) and 5-10 cm soil depth (in elevation of 2800-3000 m), respectably. For perennial soil seed composition, the higher values of 55 and 56% were obtained at 0-5 and 5-10 cm soil depth, in the middle altitude (2600-2800 m), respectively (Fig 6).

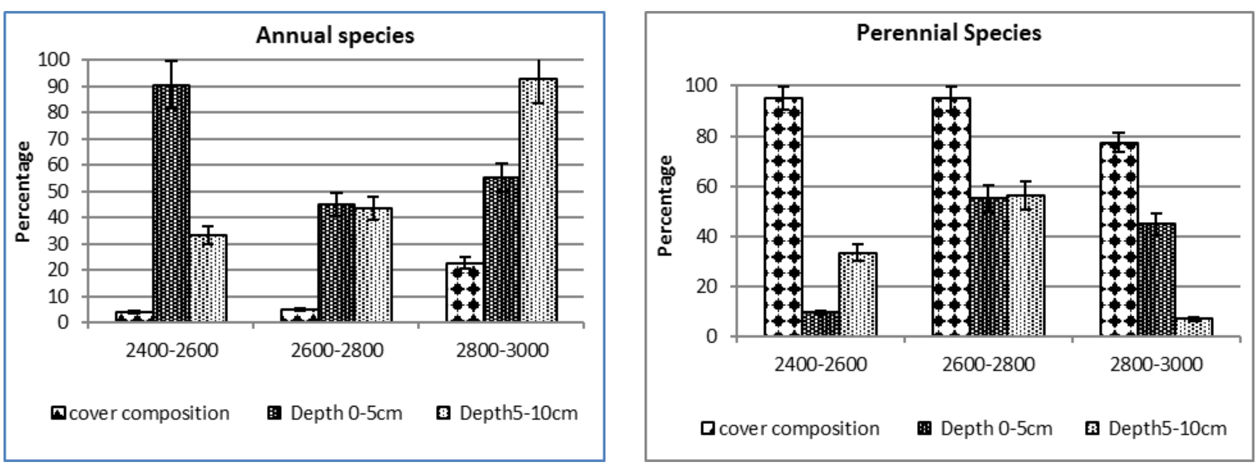


Fig. 6.Comparison of cover composition percentage, annual and perennial seed composition in three altitudes and two soil depth

Discussion

Vegetation cover

The results of greenhouse experiment showed that most of germinated seed species was belong to annual grass species while plant species on the ground are mostly perennial plants (Fig 6). Najafi Shaybankar *et al.* (2012) also examined the soil seed bank in plant communities of the GNU Protected Area, which most of germinated seeds were annual grass species, which is consistent with the results obtained in this study.

The highest and lowest percentages of cover obtained from the cover were related to *Artemisia aucheri* and *Alyssum linifolium*. The species in surface cover and seed bank of soil were classified into three groups according to their presence and absence.

The first group species that were present only in vegetation. These species are likely to have low seed banks and in greenhouse conditions, seeds of some of these species may not be capable of germination (Bossuyt and Hermy, 2004). Consequently, they were not seen in the seed bank of the soil. The second group was the common species between vegetation and seed bank. The most important reason for the presence of these species in seedlings and seed banks is due to the prolonged survival of these species in the soil. The third group of species was found only in the seed bank of soil. These species are likely to be ones that can form a durable seed bank in the soil (Bossuyt and Hermy, 2008), but conditions for germination and their growth in vegetation were not provided. Consequently, they were not observed in vegetation.

In fact, the results of aboveground vegetation and greenhouse registration showed that only 23 species in the seed bank and 13 species in the aboveground vegetation and 4 species were shared between the soil seed bank and the aboveground vegetation, which does not match with the results of Nazari *et al.*, (2014).

Due to the lack of similarity between aboveground vegetation and soil seed bank in the study area, some of the most prevalent types of plant types do not have the ability to produce seeds or have enough seed storage in the seed bank.

Plants such as *Alyssum linifolium*, *Echinops leiopolyceras*, *Crucianella gilanica* subsp. *glauca*, *Achillea santolinoides* subsp. *wilhelmsii*, *Anchusa azurea*, *Astracantha gossypina* ,*Chenopodium novopokrovskyanum*, *Chenopodium album*, *Chenopodium murale*, *Geranium kotschyi*, *Heliotropium supinum*, and *Kochia stellaris* were only in aboveground vegetation.

The lack of many perennial species in the seed bank, despite their presence in the land cover, may be related to changes in the strategy of these plants for reproduction and the use of non-sexual reproductive methods (rhizome, onion, etc.) (Reine *et al.*, 2006).

The overall result of work on the resemblance of soil seed banks and plant communities is that very turbulent ecosystems or habitats with unpredictable conditions such as crops, habitats containing corrupt materials, flood plains rivers, deserts, dry pastures and spring ponds are very similar to the vegetation cover and seed banks, and systems with less disturbances such as plains, bogs, wetlands, shrubs and (especially) old or very old forests have lower relative similarity (Hopfensberger, 2007; Luzuriaga *et al.*, 2005; Wellstein *et al.*, 2007).

Plant Density

The results of the greenhouse study showed that the sampled soil contains a limited number of seeds, both in terms of density and diversity. The highest seed density in the elevation of 2600-2800 m and in the depth of 0-5 cm,l is consistent with the results of Salariyan *et al.* (2016) and Erfanzadeh and Hosseini (2010). The reason of higher seeding density in surface depth can be related to the age and shape of the seeds, seed size, physiological requirements of the seeds, and the activity of living organisms in the soil (Yoshihara *et al.*, 2010). The results showed that there was no significant difference in density at different depths, which did not match with the result reported by Kamali *et al.* (2013).

Also, the results showed that there was no significant difference in density at different elevations. A total of 17 species were recorded in above-ground vegetation. The species such as *Bromus tectorum* and *Bromus tomentellus* and *Astragalus lycioides* accounted for a large percentage of the coating. Of course, the lack of germination of shrub species in the greenhouse and their emergence in the above-ground vegetation were significant (Table 3). Germination is strongly influenced by environmental factors (Ghavam, 2018). Mengistu *et al.* (2005) in a study of woody plant recovery in the degraded plains of northwestern Ethiopia reported that several woody species were found in standing vegetation, but they were not in the seed bank, which is consistent with the results of the study.

Diversity Indices

Species diversity is one of the important characteristics of living communities, especially the structure of societies that reflect the richness and uniformity of society (Maia *et al.*, 2012). The The results of one-way analysis of variance showed that the effect of altitude from sea level only on the Shannon's diversity was significant ($P \leq 0.05$) and soil depth on the variability of species diversity was not significant. Fisher and Fuel (2004) have given the results of their research and have considered the elevation of the sea to be effective in the diversity and richness of the species. Changes in the richness and diversity of species are characteristics of manipulated ecosystems. The higher the species diversity of an ecosystem, the greater its resistance to destructive factors because most ecological nests are already occupied and the available resources are used to the best of their ability (Jangju, 2009).

The statistical comparison of richness indices showed that the effect of soil depth on the Menhinik and Margalef richness was significant ($P \leq 0.01$ and $P \leq 0.05$) and altitude from sea level on the richness indices was not significant, which is consistent with the results given by Ma *et al.* (2010). But Hathout (2002) also concluded that species richness was significantly different at different elevations from sea level and did not match the present research. Mirzaei and Karami (2015) showed that the diversity and richness of plant species decreased with the increased elevation from sea level. Daïnou *et al.* (2011) in a study on soil seed bank characteristics in Cameroon ornamental forests showed that open canopy space had a significant effect on the soil richness of seed bank richness; these results did not match the current research.

The great similarity between the seed bank and the vegetation cover was resulted in the fact that limited diffusion has led researchers to believe that the richness of the vegetation is related to a rich seed bank (Lopez-Marino *et al.*, 2000). The reason for the low seed enrichment may be due to hunting and germination, which cannot remain in the soil for a long time (Grime, 1979).

Bonvissuto (2006) stated that the lack of emergence of seeds and their establishment in the bare area may be partly related to the extent of high soil health and the effects of wind drying throughout the day, which reduces the richness of the seed bank of the soil.

The results of analysis of variance showed that thete was not significant difference between the mean of Uniformity from different soil depth and altitude from sea level. The results in the research were consistent with the study of Nazari *et al.* (2014) and were not consistent with the results of Grell *et al.* (2005).

Nouraie *et al.* (2014) compared the seasonal variation pattern of the seed bank of the *Populus caspica* (Bornm.) Bornm.in Noor Forest Park in northern Iran; comparison of the uniformity indices showed that the uniformity of the seed bank of the soil ws more than ever in spring.

Soil seed bank similarity index indicated that height and depth had no significant effect on soil seed bank. The results showed that the soil seed bank with above-ground vegetation was not very similar; that is not consistent with the finding of Erfanzadeh *et al.* (2011). Perhaps, grazing in the study area caused a decrease in the similarity of soil seed banks with above-ground vegetation in both studied depths. The results of this study have been reported in the studies of Daneshgar *et al.* (2013).

Hosseini Kahnouj *et al.* (2015) studied the effect of soil seed bank characteristics on two habitats of grassland and forests of Vaz Area in northern Iran and found that the similarity of soil seed banks with above-ground vegetation as well as other soil seed bank characteristics was significantly higher in grassland habitats. It was a forest area that did not match the current research.

Due to the low similarity between the seed bank and the above-ground vegetation, it seems that the species present in the above-ground vegetation may have low seed bank or little seed production. As a result, seed cannot be found in soil banks, and in addition, under certain greenhouse conditions, seed of some species cannot germinate, and it may take longer to break seeds to sprout. One of the reasons for reducing the similarity can be related to decreasing seed rate with increasing depth, which reduces the similarity of seed banks and land cover. This similarity can be attributed to the time of sampling of above-ground vegetation and seed banks, reproductive strategies of plants, the durability of different seeds, destructive effects (plowing and land release), and even sampling considerations.

Conclusion

Seed is the most important and basic part of the plant that plays an essential role in the regeneration, preservation and transfer of plant genetic material as well as the mechanisms of distribution, reproduction and survival of the plant in very difficult conditions. Soil Seed Bank is the backbone of the capital of an ecosystem and its study allows the comparison of above-ground vegetation and soil seed bank for the application of different managements. The results of the present study showed that the effect of altitude as one of the Environmental factor was not significant on the diversity, density and composition of soil seed bank. According to the results of this study, most of the germinated species from the soil seed bank belonged to annual herbaceous species. The seeds of these species germinate in spring and their seeds are found during the winter, which is often dormant when they fall; dormacy is broken during a period of cold or heat and is referred to as a temporary seed bank. While most plants in above-ground vegetation were perennials, it can be seen that in the study area, mainly the seeds of perennial plants in the shallow depths of the soil are not ready for germination or should remain in the soil for a long time, which is described as a stable seed bank. To find out the reasons for the presence and absence of species in the soil seed bank, it is recommended to study the pathology of the species and to measure the input and output of the seed bank or the amount of its changes. Also, the impact of other environmental factors such as slope, geographical direction, climate, etc. in each region should be considered. In many cases, the range of seed distribution is wide and seeds may accumulate at high altitudes and will never obtain germination conditions. But moving them to the greenhouse provides the conditions for germination.

Due to the sampling method and the conditions of the study area, the discrepancy between the species observed in the seed bank and the species present in the area is quite predictable and justifiable. Seed production is very high in grasses, especially annual grasses. Therefore, in arid and semi-arid regions, we expect the seed bank to be more dependent on these plants. On the other hand, seed germination of perennial plants, especially shrubs requires more special conditions. Meanwhile, annual grasses begin to grow rapidly with minimal germination conditions. Also, the density of annual grasses is much higher than perennial plants and again, more seeds can be justified in the seed bank.

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چکیده. بخشی از ترکیب گیاهان در اکوسیستم‌های طبیعی به عنوان بذور زنده در بانک بذر خاک پنهان است. شناسایی این منبع گونه‌ای نقش مهمی در محافظت و احیای پوشش گیاهی دارد. مطالعه حاضر با هدف بررسی بانک بذر خاک و ارتباط آن با پوشش گیاهی سطح زمین در امتداد طبقات ارتفاعی در کاشان، ایران انجام شده است. برای نمونه‌برداری از بانک بذر خاک، سه ترانسکت به طول ۲۰۰ متر (دو ترانسکت به موازی ارتفاع و یک ترانسکت عمود بر ارتفاع) ایجاد شد. نمونه‌های خاک از دو محدوده عمق ۵-۰ و ۵-۱۰ سانتی متری از پلات های یک مترمربعی که در فاصله ۲۰ متری از یکدیگر قرار گرفته بودند، در آذر سال ۱۳۹۶ برداشت شد. سپس نمونه های خاک به گلخانه منتقل و در آنجا کشت شدند. علاوه بر این، درصد پوشش گونه های گیاهی موجود در هر قطعه نیز در بهار سال بعد ثبت شد. ویژگی‌های بانک بذر خاک در ارتفاع‌های مختلف با استفاده از آزمون F مقایسه شد. نتایج تحلیل واریانس یک طرفه نشان داد که تأثیر ارتفاع از سطح دریا بر تنوع شانون در سطح احتمال خطای ۵ درصد و تاثیر عمق خاک بر تراکم، غنای منهینیک و مارگالف به ترتیب در سطح احتمال خطای ۵ و یک درصد معنی‌دار بود. بیشترین مقدار تنوع شانون در بالاترین طبقه ارتفاعی (۲۸۰۰-۳۰۰۰ متر از سطح دریا) و بیشترین مقدار تراکم، شاخص‌های مارگالوف و منهینیک در عمق ۰-۵ سانتی متری خاک بدست آمد. نتایج آزمایشات گلخانه‌ای نشان داد که بیشتر بذرهای جوانه زده به گونه‌های علفی یک ساله تعلق دارند. در حالی که در پوشش سطح زمین، اکثر گونه‌ها مربوط به گیاهان چند ساله است. بیشترین درصد پوشش متعلق به *Artemisia aucheri* از طبقه ارتفاعی ۲۶۰۰-۲۸۰۰ متر از سطح دریا بود و کمترین درصد پوشش متعلق به *Alyssum linifolium* در طبقه ارتفاعی ۲۸۰۰-۳۰۰۰ متر از سطح دریا بود .بنابراین می توان نتیجه گرفت که در منطقه مورد مطالعه، بذر گیاهان چند ساله آمادگی لازم برای جوانه زنی در اعماق خاک را ندارند یا باید مدت طولانی در خاک بمانند و به عنوان بانک بذر پایدار توصیف می شوند.

کلمات کلیدی: ارتفاع، جوانه‌زنی، تراکم، تنوع ، بانک بذر خاک