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Relationship Between Soil Seed Bank and Above-ground Vegetation of a Mixed-deciduous Temperate Forest in Northern Iran

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ABSTRACT

We assessed the size and composition of the soil seed bank and above-ground vegetation in 52 relevés representing a range of habitats within an old- growth, temperate deciduous forest at Hyrcanian region, northern Iran. We identified 63 taxa in the seed bank, with an average density of 4202 seeds/spores per m^2 by seedling emergence method. *Hypericum androsaemum*, *Cardamine impatiens*, *and Rubus hyrcanus,* with *Athyrium flix- femina* and *Pteris cretica* as two ferns, were the most abundant species in the seed bank and spore bank that made up to 92 % of the seeds/spores recorded in the soil seed bank. Totally, 107 species were recorded in the vegetation and soil seed bank of the study site, of which 33 % were common in both seed bank and vegetation and 26 % and 41 % were found only in the seed bank or in the vegetation, respectively. The dominant tree species with many woody understory species found in the above- ground vegetation were absent from the persistent soil seed bank. Jaccard's similarity coefficient revealed that the correspondence between the species in the vegetation and the same species in the seed bank were consistently low (average of 24.3%) based on presence/absence data. Yates- corrected χ^2 test showed that sites present significant differences (P<0.001) in seed bank and vegetation species composition. DCA ordination of the above-ground vegetation and soil seed bank flora displays a clear pattern, with two distinct groups on the basis of the above-ground vegetation and soil seed bank floristic data. Our results explain the low similarity between soil seed bank and vegetation of the Darkola oriental beech (*Fagus orientalis* Lipsky) forest only to a limited extent, but confirm that most of the species of the above-ground vegetation do not depend on the persistent soil seed bank. Therefore, it may be concluded that the persistent soil seed bank is not capable of restoring the extant vegetation of the studied site.

Keywords: Soil seed bank, Above-ground vegetation, Old- growth forest, Ordination, Oriental beech, Temperate deciduous forest

INTRODUCTION

A soil seed bank is defined as the seeds that can remain dormant for a period of time in the soil until their germination is triggered by an environmental change (Simpson *et al.,* 1989). Furthermore, soil seed banks are considered as essential constituents of plant communities (Harper, 1997). Seed bank studies can provide important information for restoration and management purposes (Katharina *et al.*, 2009). The soil seed bank represents the regeneration potential of the plant communities and it is regarded as a memory of the former plant community; thus, it could be important for conservation and restoration of species and plant communities (Bakker *et al.,* 1996). There is in an increasing demand for reliable information on seed banks, both for scientific purposes and as a decision tool in habitat and landscape management, particularly restoration projects (Holzel and Otte, 2004). Soil seed banks play an important role in

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restoring former species diversity (Bakker *et al.,* 1996). Seeds of the target species may have survived beneath degraded plant communities. It has also been shown that the risk of local extinction increases in species with short-lived seed banks, particularly in fragmented landscapes (Stocklin and Fischer, 1999).

Thompson *et al.* (1997) suggested a classification for seed bank types using the criterion of seed longevity: transient: < 1 yr; short-term persistent: 1-5 yr; long-term persistent: > 5 yr. Only the latter category could play a significant role in the restoration of species richness. Thus, soil seed bank persistence is a key factor in the regeneration of plant communities (McDonald *et al*., 1996; Bekker *et al.,* 1998) and for the assessment of the local extinction risk (Stocklin and Fischer, 1999). The capability of plant species to produce seeds remaining viable in the soil allows them to bridge temporally favorable habitat conditions for germination and establishment, spreading germination risk in time and conserving population genetic variation in the long term (Bossuyt and Honnay, 2008). Similarity between the above-ground vegetation and the soil seed bank has also been examined in several studies, along which a low similarity was documented (Thompson and Grime, 1979; Looney and Gibson, 1995). The composition and abundance of soil seed bank species, as well as the distribution of life forms, are influenced by factors such as floristic composition, the phenology of the local vegetation, and disturbances occurring at the forest edge (Butler and Chazdon, 1998). The size, composition, structure, and the dynamics of the soil seed banks are key factors for community regeneration and ecological restoration. Therefore, the functional role of soil seed banks in determining the structure of the vegetation and the persistence at European temperate forests has been considered in various studies (Onaindia and Amezaga, 2000; Zobel *et al.,* 2005; Bossuyt *et al.,* 2008 and Chaideftou *et al.,* 2009). Nevertheless, no information is available on the soil seed bank of the Caspian or Hyrcanian temperate forests in northern Iran.

Caspian or Hyrcanian forests cover an area of 1.9 million hectares in Iran and cover additionally 20000 hectares in the Republic of Azerbaijan. In the northern part of Iran, these forests extend along the south coast of Caspian Sea, and are characterized by high growth capacity due to fertile soils and humid temperate climate with annual rainfall ranging from 700 to 2000mm (Marvie Mohajer, 2004). Dominant tree species of these forests include oriental beech (*Fagus orientalis* Lipskey), oak (*Quercus castaneifolia* C. A. May.) and hornbeam (*Carpinus betulus* L.). Depending on the site conditions, other constituent species are the following; *Acer velutinum* Boiss, *Tilia platyphyllos* Scop., *Fraxinus excelsior* L. and *Alnus subcordata* C. A. May. *Fagus orientalis* is the most important tree species in Hyrcanian forests of northern Iran, occurring at 700 m. to 2200m a.s.l and forming the most important and the richest forests in the Hyrcanian region. Based on their floristic composition, oriental beech forests of this region are linked with European forests, with major affinities with Balkans beech forests (Assadollahi, 2001). The Caspian beech communities occur at the eastern-most part of the distribution range of the oriental beech (Sageb- Talebi *et al.,* 2003).

This study aims to describe the floristic- physiognomic features of the above-ground vegetation and the soil seed bank composition of a Hyrcanian intact old growth temperate deciduous forest with *Fagus orientalis* in Darkola, situated in the centre of Mazandaran Province. No disturbance or exploitation, grazing, and other destructive human interventions have ever been recorded in this forest, which make it a desirable site to study soil seed banks in climax forest communities. More specifically, objectives of this study are: (1) to describe the vascular flora composition, growth- and life- forms, of the field layer of the above-ground, as well as of the soil seed bank vegetation; (2) to determine the soil seed bank composition and species density and (3) to assess the relationship between the above-ground vegetation and seed bank species composition.

MATERIAL AND METHODS

Study Area

The research area is an old growth temperate deciduous forest in Darkola, in Hyrcanian or Caspian forests of northern Iran (latitude: 36°8ʹ N, longitude: 53° 6ʹ E and elevation 1050 to 1750m above sea level). Darkola forest is located in the middle part of Caspian forest and is intact. Mean annual temperature and precipitation are 13°C and 1200 mm, respectively (Anonymous, 2002).

Data Collection

Above-ground vegetation was investigated in 52 plots of 400 m^2 at the peak of vegetation period in the spring of 2007. Sample plots were positioned by systematic-selective method in 100 and 200 meter grid dimensions, considering indicator stands concept. However, if the center of the network in the field was not within a representative stand, the plot was positioned in the nearest stand of beech. Relevés were made in each plant community, using marked permanent plots of 20 m x 20 m (400 m^2); tree- and shrub- cover was estimated within the entire plot area. Herbaceous species were recorded in (a) 20 quadrats (5 m^2), which were distributed as follows: one at the center and the remaining four at the corners of the sample plot, (b) 5 cluster subplots with 4 quadrats of 5 m^2 each (4 × 5 subplot = 20 quadrats representing a total of 100 m^2 subplot for herbaceous plants) (Figure 1).

To assess the persistent seed bank composition, we collected soil samples at the end of May 2007, when germination had ended and before new seeds were dispersed (Baskin and Baskin, 1998). Within each plot, six seed bank samples were randomly collected, resulting in a total of 312 soil samples. Seed banks samples were collected by hammering a hollow 20 cm × 20 cm square (400 cm^2) metal frame into the soil to a depth of 10 cm. Thus, in each plot, an area of 2400 cm^2 of soil was sampled. The litter layer was included with the soil samples because this layer could contain a high number of seeds (Leckie *et al.,* 2000). Each sample was separated into two collection bags: organic LFH material and mineral soil. The bags were stored wet in a refrigerator in the dark at 3-4°C, for 3 months to cold stratify the seeds (Chaideftou *et al.,* 2009). During the first week of October 2007, the samples were transported to the greenhouse for seed bank determination.

The seedling emergence method is the most frequently used, and the more reliable method, in soil seed bank studies (Baskin and Baskin, 1998). Thus, it was used in the present study for determining the species composition of the soil seed bank, assuming

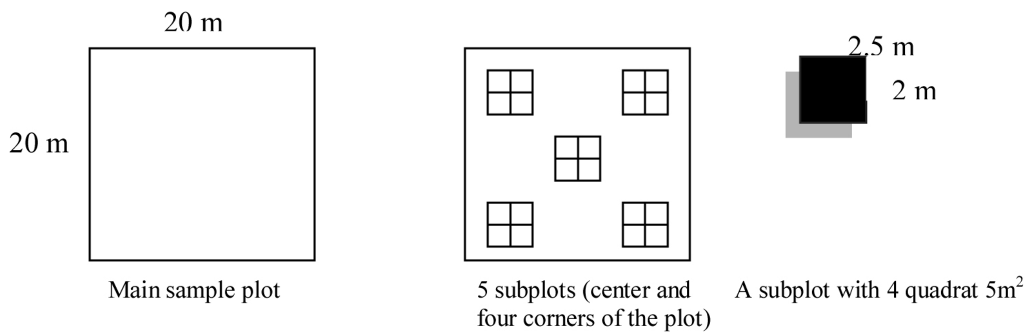

Figure 1. Size, schematic arrangement of the main sample plot and the subplots, and their quadrats.

that the number of seedlings detected by this method is the number of the buried viable seeds, which would indicate the number of the readily germinable seeds in the soil. Soil samples were spread out on a 5 cm thick layer of sterilized sand in a 40 cm × 40 cm plastic seed tray, forming an approximately 2.5 cm thick layer. Leaf litter was shaken and the seeds present were added to the soil samples (Leckie *et al.,* 2000). Twenty seed trays containing only sterilized sand were placed among the sample trays to test for contamination by local seeds. In the course of the germination test, no seedlings were found in these control trays. The seed trays were kept continuously moist by daily watering and, to avoid differences in light exposure, the position of the trays was changed every 2 weeks. Every week, all seed trays were checked for seedlings. Newly emerged seedlings were determined, counted, and removed from the trays. Unidentifiable seedlings were transplanted into pots and grown until species identification was possible (Diaz-Villa *et al.*, 2003). Soil samples were maintained and checked for emerging seedlings for approximately 1 year, since a shorter period of study could result in an underestimation of the persistent seed bank (Baskin and Baskin, 1998). During this period, soil samples were stirred five times to bring any non germinated seeds to the surface in order to increase the possibility of seeds to be exposed to light. Total number of seedlings that emerged was used as the measure of viable seeds in the seed bank.

Data Analysis

The total number of seedlings germinating per tray were summed for each plot (six trays per plot) and retained for analysis. Seedling totals are expressed as seed density per m^2. Similarity in species composition between seed bank and above-ground vegetation was assessed by Jaccard's similarity index (Greig-Smith, 1983).

The relative cover, or the relative seed density for each plot, was calculated as the herb layer cover of the above-ground vegetation or the seed density in the soil seed bank divided by the total cover or total seed density in that plot. The relationship between species composition in the ground layer vegetation and in the soil seed bank was further explored by means of Detrended Correspondence Analysis (DCA; Hill and Gauch, 1980) using modified original cover values of the species and density of the germinants for vegetation and seed bank data, respectively. DCA is generally the most widely used (Kent and Coker, 1995) and cited ordination technique in ecological literature and has distinct advantages for our application in these forest stands, since the species are ordinated simultaneously and the computational requirements are small. Prior to analysis, seed bank density data and original cover values of vegetation data were separately modified by the maximum value modification for preventing any bias to the species with high values i.e. seed bank density or cover value. By this adjustment, seed bank density and cover percentage values were transformed in the range of 0 to 1 (McCune and Mefford, 1999). To avoid artifacts arising through under-sampling of less frequent taxa in the seed bank, only the taxa that were found in three or more plots were included in the DCA analysis. Rare species were downweighted to reduce distortion of the analysis. Following this procedure, sample plots were ordinated in both above-ground vegetation and soil seed bank data, in order to obtain the pattern of variation in the seed bank and vegetation data.

For ordination of the soil seed bank and above-ground vegetation data, CANOCO 4.0 (ter Braak, 1988) was used; plots were drawn by CANODRAW 3.0 (Smilauer, 1993). Yates- corrected χ^2 test was done to compare seed bank floristic composition with the standing vegetation (Arriaga and Mercado, 2004).

RESULTS

Above-ground Vegetation Composition and Life Form

The above-ground vegetation comprised 79 plant taxa belonging to 71 genera and 44 families (Table 1). The families with the higher number of species, namely, *Labiatae* and *Asteraceae* (with 8 species), *Rosaceae* and *Poaceae* (with 7 species), *Aspidiaceae* and *Liliaceae* (with 5 species), comprise 74 % of the total above-ground flora. Growth-forms classification of the present vegetation (Table 2), showed their participation with the following percentages: forbs: 30 taxa, trees: 19 taxa, ferns: 13 taxa, grasses: 7 taxa, shrubs and semi-shrubs: 6 taxa, and lianas: 5 taxa in the above-ground vegetation of the study area. *Fagus orientalis* Lipsky and *Carpinus betulus* L. as tree species and *Ruscus hyrcanus* Woron., *Ilex spinigera* (loes) Loes and *Danae racemosa* (L.) Moench as shrub species with *Solanum kieseritzkii* C. A. May and *Mercurialis perennis* L. as forb species were the most frequent and dominant species in the overstorey and understorey of the extant vegetation, respectively. *Alnus subcordata* C. A. May, *Acer velutinum* Boiss. and *A. cappadocicum* Gled., were the companion tree species in the overstorey. Biological spectrum of the ground vegetation following Raunkiaer's system shows that phanerophytes (35 %), cryptophytes (33.8 %), and hemicryptophytes (26.2 %) were the dominating life-forms in the extant vegetation, while chamaephytes and therophytes add only 2.5 % in the above-ground vegetation (Figure 1).

Seed bank density and diversity

A total of 28931 seedlings belonging to 63 plant species, representing 57 genera and 36 families, were recorded in the seed bank soil samples (Table 1). Of these, forbs comprised the largest group, with just over 70 % of the total species. Fern gametophytes were the next most abundant group among the emerged seedlings making up approximately 11 % of the total taxa, while woody plants and graminoids comprised only 9.5 % of the total richness of the emerged seedlings (Table 2). The average seed density for all study sites was 4202 seeds per m^2. The most abundant species in the seed bank were *Hypericum androsaemum* L. (1590 seeds per m^2), *Cardamine impatiens* L. (570 seeds per m^2), *and Rubus hyrcanus* Woron (286 seeds per m^2). The high numbers of spores of *Athyrium flix- femina* (L.) Roth. (1277 seeds per m^2) and *Pteris cretica* L. (151 seeds per m^2) were also remarkable. These five species made up to 92 % of seeds recorded in the soil seed bank samples. Biological spectrum of the soil seed bank with Raunkiaer's system shows that phanerophytes (35 %), cryptophytes (33.8 %) and hemicryptophytes (26.2 %) were the dominating life-forms in the extant vegetation, while chamaephytes and therophytes add only 2.5 % in the above-ground vegetation (Figure 2).

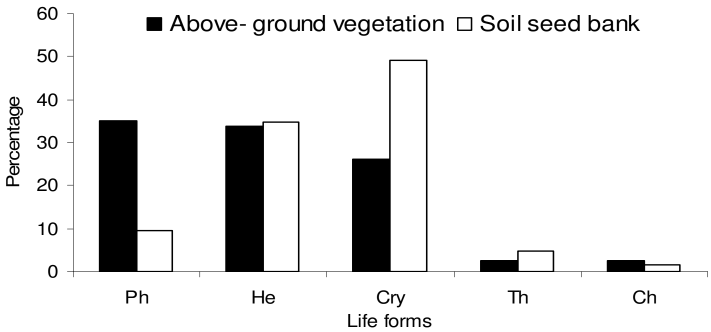

Figure 2. Biological spectrum of the soil seed bank and the above-ground vegetation of Darkola Oriental beech forest.

Table 1. Floristic composition, life-forms and constancy of soil seed bank and above-ground vegetation of the Darkola Oriental forest, Northern Iran.

Species	Abbreviation	Species performance			Life form	Seed bank	
		seed bank only	seed bank and Vegetation	vegetation only		Mean density (per m²)	constancy
Acer cappadocicum	Acer cap			*	Ph		
Acer velutinum	Acer vel			*	Ph		
Asplenium trichomanes	Aspl tri			*	Cry		
Blechnum spicant	Blec spi			*	Cry		
Carex riparia	Care rip			*	Cry		
Carpinus betulus	Carp bet			*	Ph		
Cephalanthera caucasica	Ceph cau			*	Cry		
Cerasus avium	Cera avi			*	Ph		
Clinopodium umbrosum	Clin umb			*	He		
Cornus australis	Corn aus			*	Ph		
Crataegus microphylla	Crat mic			*	Ph		
Danae racemosa	Dana rac			*	Ph		
Daphne mezereum	Daph mez			*	Ph		
Digitalis nervosa	Digi ner			*	Th		
Diospyrus lotus	Dios lot			*	Ph		
Dryopetris borreri	Dryo bor			*	Cry		
Dryopetris filix- mas	Dryo fil			*	Cry		
Epipactis helleborine	Epip Hel			*	Cry		
Evonymus latifolia	Evon lat			*	Ph		
Fagus orientalis	Fagu ori			*	Ph		
Frangula alnus	Fran aln			*	Ph		
Geranium robertianum	Gera rob			*	He		
Ilex spinigera	Ilex spi			*	Ph		
Lapsana communis	Laps com			*	He		
Lathyrus vernus	Lath ver			*	Th		
Mateuccia strothiopteris	Mate str			*	Cry		
Mespilus germanica	Mesp ger			*	Ph		
Paeonia wittmanniana	Paeo wit			*	Cry		
Periploca graeca	Peri gra			*	Ph		
Polygonatum orientale	Poly ori			*	Cry		
Polystichum aculeatum	Poly acu			*	Cry		
Polystichum woronowii	Poly wor			*	Cry		
Prunella vulgaris	Prun vul			*	Cry		
Prunus divaricata	Prun div			*	Ph		
Quercus petraea	Quer pet			*	Ph		
Quercus castaneifolia	Quer cas			*	Ph		
Ruscus hyrcanus	Rusc hyr			*	Ph		
Serratula quinquefolia	Serr qui			*	Cry		
Solidago virga- aurea	Soli vir			*	He		
Sorbus torminalis	Sorb tor			*	Ph		
Taxus baccata	Taxu bac			*	Ph		
Ulmus glabra	Ulmu gla			*	Ph		
Vaccinium arctostaphylos	Vacc arc			*	Ph		
Vicia cracca	Vici cra			*	Ch		
Alnus subcordata	Alnu sub		*		Ph	6.8	35.3
Asperula odarata	Aspe oda		*		He	2.8	21.6
Asplenium adiantum-nigrum	Aspl adi		*		*Cry*	0.2	1.9
Athyrium flix- femina	Athy fli		*		Cry	1277	100
Brachypodium pinnatum	Brac pin		*		He	2.7	15.7
Brachypodium sylvaticum	Brac syl		*		He	0.9	9.8
Calystegia sepium	Caly sep		*		He	0.6	5.9
Cardamine impatiens	Card imp		*		He	570	100
Carex remota	Care rem		*		Cry	43	74.5

To be continued…

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Table 1. Continued**.**

Species	Abbreviation	Species performance: seed bank only	Species performance: seed bank and Vegetation	Species performance: vegetation only	Life form	Seed bank: Mean density (per m^2)	Seed bank: constancy
Carex sylvatica	Care syl		*		Cry	20.5	54.9
Circaea lutetiana.	Circ lut		*		He	1	11.8
Cyclamen coum	Cycl cou		*		Cry	4.7	33.3
*Dryopetris dillat*ata	Dryo dil		*		Cry	0.6	3.9
Euphorbia amygdaloides	Euph amy		*		He	0.5	5.9
Festuca drymeia	Fest dry		*		Cry	10.9	15.7
Fragaria vesca	Frag ves		*		He	2.3	25.5
Galium aparine	Gali apa		*		He	1.2	9.8
Hedera pastuchovii	Hede pas		*		Ph	0.2	1.9
Hypericum androsaemum	Hype and		*		Ph	1590	100
Lamium album	Lami alb		*		He	45.1	68.6
Mercurialis perennis	Merc per		*		Cry	2.1	11.7
Oplismenus undolatifolius	Opli und		*		He	1.1	1.9
Petasites hybridus	Peta hyb		*		Cry	0.9	5.9
Phyllitis scolopendrium	Phyl sco		*		Cry	0.3	1.9
Primula heterochroma	Prim het		*		He	10	29.4
Pteris cretica	Pter cre		*		Cry	151.5	94
Rubus hyrcanus	Rubu hyr		*		Ph	285.7	100
Salvia glutinosa	Salv glu		*		He	2	3.9
Scrophularia vernalis	Scro ver		*		He	6.7	15.7
Scutellaria tourneforteii	Scut tou		*		He	0.2	1.9
Sedum stoloniferum	Sedu sto		*		He	3.3	13.7
Solanum kieseritzkii	Sola kie		*		Ch	4.4	25.5
Tamus communis	Tamu com		*		Cry	0.3	1.9
Tilia platyphyllos	Tili pla		*		Ph	0.3	3.9
Urica dioica	Uric dio		*		Cry	1.6	17.6
Viola alba	Viol alb		*		He	4.1	31.4
Alliaria petiolata	Alia pet	*			He	0.5	3.9
Atropa belladonna	Atro bel	*			He	22	62.7
Ajuga reptans	Auju rep	*			He	0.3	3.9
Calamintha officinalis	Cala off	*			He	24.3	51
Carex sp.	Care sp.	*			Cry	13.1	39.2
Conyza canadensis	Cony can	*			He	9.2	72.5
Corydalis hyrcana	Cory hyr	*			Cry	0.3	3.9
Digitaria sanguinalis	Digi san	*			Cry	2.1	23.5
Hypericum hyssopifolium	Hype hys	*			He	0.5	5.9
Hypericum perforatum	Hype per	*			He	0.2	1.9
Juncus sp.	Junc sp.	*			Cry	19.8	35.3
Luzula forsteri	Luzu for	*			Cry	12.7	45.1
Melilotus officinalis	Meli off	*			He	0.2	1.9
Mentha aquatica	Ment aqu	*			He	2.9	11.7
Oxalis corniculata	Oxal cor	*			Th	0.5	5.9
Plantago sp.	Plan sp.	*			Th	0.2	1.9
Poa bulbosa	Poa bul	*			Cry	13	35.3
Portoloca oleracea	Port ole	*			Th	0.2	1.9
Pteridium aquilinum	Pter aqu	*			Cry	0.2	1.9
Rumex sp.	Rume sp.	*			He	0.5	3.9
Salix aegyptiaca	Sali aeg	*			Ph	0.2	1.9
Sambacus ebulus	Samb Ebu	*			He	3.5	33.3
Solanum nigrum	Sola nig	*			He	0.2	1.9
Sonchus oleraceus	Sonc ole	*			He	0.2	1.9
Stellaria media	Stel med	*			Cry	22.1	47
Thlypteris palustris	Thly pal	*			Cry	0.9	7.8
Veronica serpyllifolia	Vero ser	*			He	0.2	1.9

Table 2. Growth-form spectrum for the soil seed bank and the above-ground vegetation of Darkola Oriental beech forest.

Growth form	Soil seed bank		Above-ground vegetation	
	Number of species	Percentage	Number of species	Percentage
Forb	44	70	30	37.5
Gross	6	9.5	7	8.7
Fern	7	11	13	16.3
Liana	0	0	5	6.2
Shrub and Bush	5	7.9	6	7.5
Tree	1	1.6	19	23.8
Richness	63	100	80	100

Relationship Between Seed Bank and Vegetation

As a total, 107 species were recognized in the vegetation and the soil seed banks of the study site, of which 33 % were common in both the seed banks and vegetation, 26 % and 41 % were found only in the seed bank or in the above-ground vegetation, respectively (Figure 3). The forest plant diversity was mostly composed of herbaceous species belonging to different families: *Labiatae* (6), *Poaceae* (6), *Asteraceae* (4), Cyperaceous (3), *Hypericaceae* (3) and *Solanaceae* (3), among others. A total of 44 plant species recorded in the vegetation were not present in the soil seed bank, including the species characteristic of old beech stands of the Hyrcanian temperate deciduous forests such as *Fagus orientalis* and *Carpinus betulus,* in the overstorey, and *Ilex aquifolium*, *Ruscus hyrcanus,* and *Danae racemosa,* in the understorey. The presence of 28 species recorded as viable seeds buried in the soil, but not found as adult plants in the vegetation, should be noted. Among them, 23 species such as *Rubus hyrcanus, Atropa belladonna, Poa bulbosa, Juncus sp., Urtica dioica, Digitaria sanguinalis,* and *Mentha aquatica* occur sparsely outside the vegetation sample plots in natural gaps or road verges, while others (*Sambucus ebulus, Conyza canadensis*, *Thelypteris palustris, Portulaca oleracea* and *Pteridium aquilinum*) are characteristic to the disturbed sites in the forests (clear cuts) and never previously seen in the site.

Based on the vegetation cover and germinant density, the DCA ordination diagram is presented in Figure 4. Soil seed bank and vegetation samples were clearly clustered along the two ordination axes. The first axis explained 31.8 % and the second axis 17.3 % of the total variation. The ordination of vegetation and soil seed bank flora were distinct in composition and displayed a clear pattern (Figure 4). Yates- corrected $\chi 2$ was estimated 23 from basis of above ground vegetation data versus seed bank

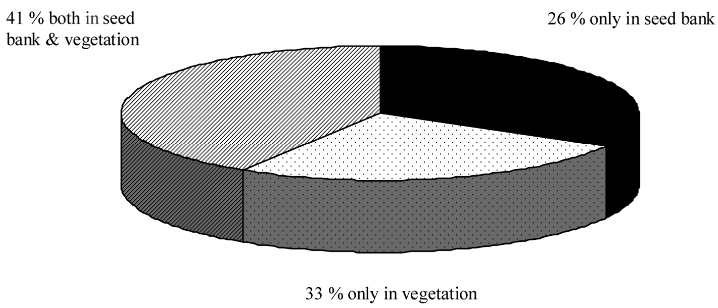

Figure 3. Soil seed bank and vegetation floristic composition of Darkola Oriental beech forest.

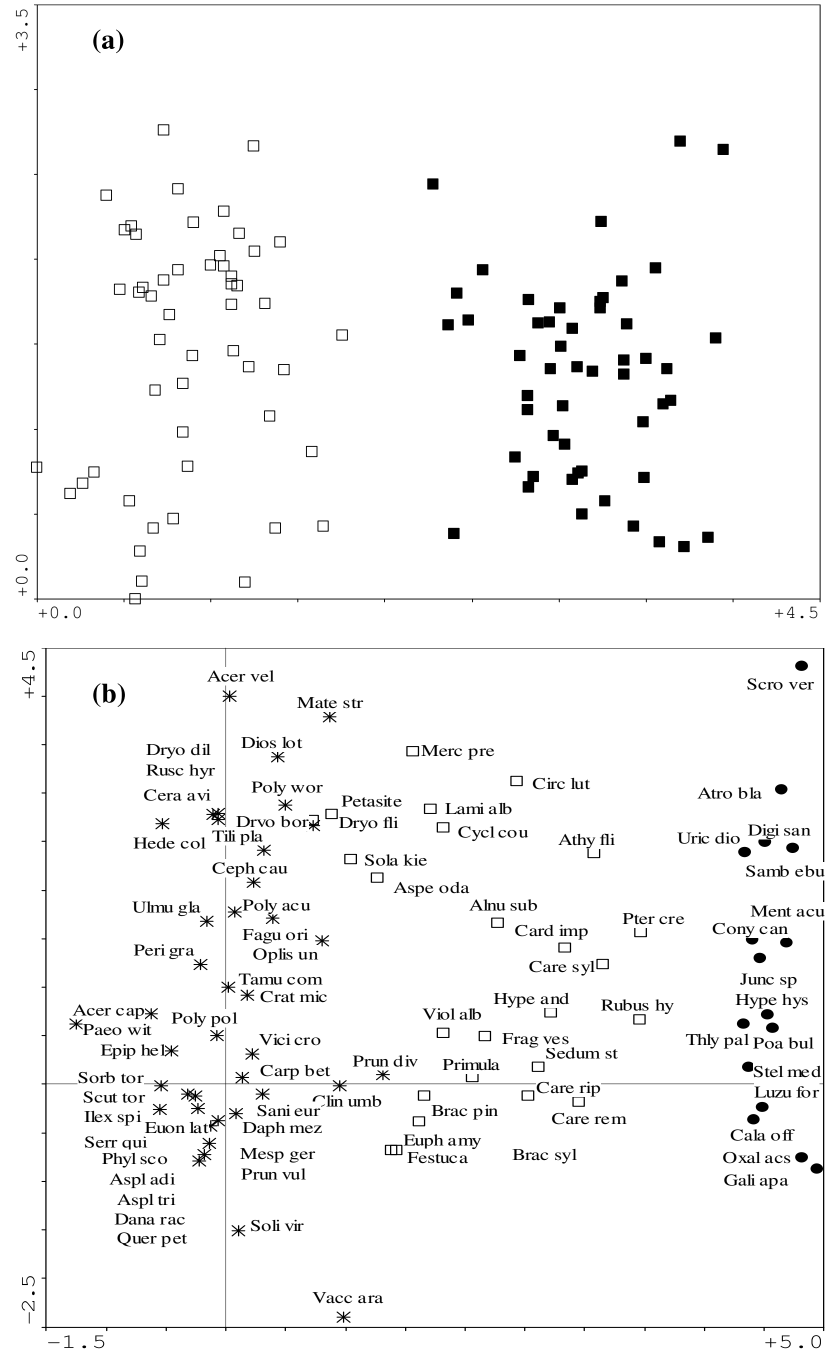

Figure 4. Ordination (DCA) diagram of 52 samples upon seedling density from the soil seed bank and vegetation cover of relevés. **(a)** Relevés ordination; Plots are displayed as: (■) seed bank plots; (□) vegetation plots **(b)** Species ordination; (*) Species only found in the vegetation; (□) Species found in both seed bank and vegetation and (●) Species only found in the seed bank. The species are labeled by the first four letters of the generic name and the first three letters of the species. Abbreviations: Refer to table 1.

present/absent floristic data. These indexes clearly indicated that seed bank floristic has significantly relation to above ground vegetation (p<0.01). Despite being the significant relationships among extant vegetation with both seed bank floristic data but the type of these relations were negatively assessed. As in Table 3 is shown the observed frequencies of the common occurrences of the extant vegetation floristic with seed banks are 27. However the expected frequencies of the common occurrences of plant species in the above ground vegetation with seed bank ((80×63)/107=47.1) compared with the corresponding observed frequencies, 27 species, indicate that above ground vegetation and soil seed banks vegetation did not occur together.

DISCUSSION

The Darkola oriental beech forests constitute an intact old- growth temperate forest that could syntaxonomically be classified in the *Querco-Fagetea* class, *Ilico-Fagetalia* order and *Rubo-Fagion* alliance (Assadolahi, 2001). The great percentages of hemicryptophytes, phanerophytes, and cryptophytes within the studied forest emphasize its indicator value as a temperate forest. High number of fern species indicate the high humidity in this forest, compared to the low contribution of therophytes, which are indicators of arid or semi- arid regions. The presence of a species in the above-ground vegetation does not ensure that a seed bank will also be present for that species. Approximately 55 % of the taxa found in the vegetation did not occur in the persistent soil seed bank of the study area; on the other hand, 43 % of the soil seed bank taxa were not found in the above-ground vegetation. The absence of above-ground flora species from the persistent seed bank suggests that seeds of most of the species remain viable on the forest floor for less than one year. This confirms the generally low similarity between above-ground vegetation and persistent soil seed bank floras in forest ecosystems and that the above-ground vegetation does not necessarily reflect the soil seed bank composition (Chaideftou *et al.,* 2009).

The seed richness and densities in our study are occasionally higher than those reported for other deciduous forests. For example, seed densities ranging from 1000-4500 seed/m^2 from the transient and the persistent seed banks of temperate forests were found in northwestern Switzerland with species richness equal to 39 plants (Amrein *et al.,* (2005). Leckie *et al.* (2000) reported 1218 seed/m^2 and 40 species in the soil seed bank of an old-growth temperate deciduous forest at Mount St. Hilarire, Quebec. Bossuyt and Hermy (2001) reported an average of 3083 seed/m^2 and 20 species in temperate forest of Central Belgium**.** However, our results on the seed bank size may be lower than what has been found in other seed bank studies of the other types of temperate forests, which were carried out after seed rain and before the growing season. For example, Godefroid *et al.* (2006) reported 10772 to 12047 seed/m^2 in the temperate oak and beech forests of central

Table 3. Yates- corrected χ^2 test result for comparisons of seed bank composition and above-ground vegetation of the Darkola oriental beech forest

Only seed bank species richness	Both seed bank and vegetation	Only vegetation species richness	Total richness	Yates-corrected χ^2	P-value	$N_{obs.}$	$N_{exp.}$	Occ. type
27	36	44	107	23	< 0.01	36	47.1	–

$N_{obs.}$= Observed frequency of the common occurrences
$N_{exp.}$= Expected frequency of the common occurrences
Occ. type=Occurrence type, It is positive (+) if $N_{obs.} < N_{exp.}$ and it is negative (-) if $N_{obs.} > N_{exp.}$

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Belgium, though their data were based on both transient and persistent seed bank. From the point of view of species richness, our seed bank richness was relatively higher than the European temperate forest seed banks.

Large-seeded late-successional species were consistently absent in the persistent soil seed bank of the study area. *Fagus orientalis*, *Carpinus betulus*, and *Acer velutinum,* as the overstory tree species, and *Ruscus hyrcanus*, *Danae racemosa,* and *Ilex spicigera,* as the main understorey species, were never found in the soil seed banks, although they were abundant in the ground vegetation. As expected, the large seeds of these species can not accumulate in the soil, because almost all of their viable seeds germinate in spring. Among the species observed at the study site, only two woody species, namely, *Alnus subcordata* and *Rubus hyrcanus*, were present and this confirms the fact that woody species in temperate habitats generally do not produce long-lived seeds and persistent soil seed bank. This is similar to other studies in temperate forests, which report only few tree taxa in the soil seed bank (Bossuyt *et al.,* 2002; Diaz- Villa *et al.,* 2003; Zobel *et al.,* 2007; and Chaideftou *et al.,* 2009). Bossuyt and Honnay (2008) affirm that few forest species produce long-lived seeds, because the stable but stressful forest environment will select for traits associated with a higher seedling establishment success rate rather than for dispersal in time or space. *Lambers et al.* (2005) agree that the greater risk of mortality at seed than seedling stage for large-seeded species may provide an evolutionary explanation for their absence from temperate forest seed banks. Arriaga and Mercado (2004) suggested that the dominant species in temperate forest communities frequently have alternative regeneration strategies, such as seedling banks or advanced regeneration, a possible reason that seeds do not necessarily enter the seed bank. The large-seeded species prefer to form seedling bank rather than seed bank, due to the lack of dormancy mechanisms. Nevertheless, light demanding species such as *Hypericum androsaceum*, *Cardamine impatiens*, *Rubus hyrcanus*, *Athyrium flix-femina* and *Pteris cretica*, comprise up to 92 % of seeds in the soil seed bank samples. These species produce small seeds and may remain viable for a long time in the soil seed bank of the European temperate forests (Onaindia and Amezaga, 2000; Bossuyt *et al.,* 2002 and Godefroid *et al.,* 2006). Some of the species recorded in the seed bank, like *Conyza canadensis*, *Urtica dioica*, *Sambucus ebulus*, *Juncus* sp., *Pteridium aquilinum,* and *Thylepteris palustris,* never occur in the extant vegetation (Table 1). These species that are characteristic of the disturbed sites or marginal lands contribute to the soil seed bank and, thus, participate in the plant diversity of the study area. In fact, in the shaded forest understorey, these light demanding species probably are no longer present in the vegetation, but their seeds may remain viable, long after the mother plant has died.

DCA ordination of the soil seed bank and vegetation samples showed that these two components were also floristically different. Indeed, this analysis showed two distinct groups as the plant community of the above-ground vegetation and the plant community of the soil seed bank, which were distributed on the basis of their floristic differentiation. Thus, we concluded that the soil seed bank and the above-ground vegetation are quite different and the two above mentioned community types do not have any overlap in the DCA ordination diagram.

Yates- corrected χ^2 test also showed that plant species composition of the seed bank significantly differed from that of the above-ground vegetation. This finding documents also statistically that the seed bank is a poor predictor of the vegetation composition in the Darkola oriental beech forest. As a concluding remark, we stress that our findings suggest that the restoration of the typical forest species of this old-growth temperate forest solely by diaspores (seeds

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and spores) stored in the persistent soil seed bank is unlikely.

CONCLUSION

The present study has shown that the soil seed bank can only be expected to have the potential to regenerate earlier successional stage plant species. This means that persistent soil seed bank can not contribute to the regeneration of the desired typical forest species.

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ارتباط میان بانک بذر خاک و پوشش گیاهی رو زمینی در یک جنگل معتدله خزان کننده آمیخته در شمال ایران

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چکیده

در این تحقیق ترکیب گیاهی و اندازه بانک بذر خاک و ارتباط آنها با ترکیب پوشش گیاهی رو زمینی تعداد ۵۲ رولوه از یک جنگل معتدله خزان کننده دست نخورده که نماینده ای از جنگل های هیرکانی در شمال ایران می باشد ارزیابی گردید. در مطالعه بانک بذر خاک با استفاده از روش پیدایش نهال، تعداد ۶۳ گونه گیاهی با متوسط تعداد ۴۲۰۲ بذر/ هاگ در متر مربع ثبت و شمارش گردید. گونه های متامتی *(Hypericum androsaemum)*، کاردامین *(Cardamine impatiens)* و تمشک *(Rubus hyrcanus)* به همراه دو گونه سرخس ماده *(Athyrium flix- femina)* و سرخس پنجه ای *(Pteris cretica)* با اختصاص دادن ۹۲ درصد از نهال های رویش یافته به ترتیب به عنوان فراوان ترین گونه های گیاهی بانک بذر و بانک هاگ خاک منطقه محسوب می شوند. به طور کلی در سطح منطقه تعداد ۱۰۷ گونه گیاهی از ترکیب پوشش گیاهی رو زمینی و بانک بذر خاک شناسایی و ثبت گردید که از میان آنها ۳۳ درصد در هر دو بخش حضور مشترک داشته و تعداد ۲۶ و ۴۱ درصد به ترتیب فقط در یک بخش بانک بذر خاک و یا پوشش گیاهی رو زمینی حضور یافتند. نتایج این تحقیق همچنین نشان داد که بذور درختان غالب منطقه به همراه بذور گونه های چوبی زیر اشکوب جنگل در بانک بذر دایمی خاک منطقه حضور نیافتند. بر مبنای ضریب تشابه جاکارد و بر اساس داده های کیفی حضور- غیاب گونه ها، درجه تشابه گونه ای ترکیب گیاهی بانک بذر خاک و پوشش گیاهی روزمینی در سطح پایین (متوسط ۲۴/۳ درصد) ارزیابی گردید. محاسبه ضریب اصلاح شده χ^2 نشان داد که میان ترکیب پوشش رو زمینی و بانک بذر خاک تفاوت معنی دار آماری وجود دارد. نتایج تحلیل رج بندی DCA نشان داد که ترکیب پوشش گیاهی رو زمینی و بانک بذر خاک در فضای دو محور اول رج بندی، دو گروه کاملا متمایز از یکدیگر را ارائه می دهند. نتایج تحقیق حاضر به طور کلی تصریح می کند که درجه تشابه گونه ای بانک بذر خاک و پوشش گیاهی رو زمینی جنگل راش دارکلا در سطح پایین بوده و عدم وابستگی تجدید حیات ترکیب گیاهی کنونی از بانک بذر خاک دایمی را تبیین می سازد. بنابراین نتیجه گیری می شود که بانک بذر خاک دایمی منطقه قابلیت احیاء ترکیب گیاهی کنونی را ندارد.

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