Role of Different Shrubs in Soil Seed Bank Conservation in Different Climates of Iran

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Role of different shrubs in soil seed bank conservation in different climates of Iran

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Abstract

Shrubs often produce positive effects on understory soil seed bank (SSB) characteristics. However, the effect of shrubs on SSB could be variable in different habitats depending on the climate and the type of shrub. In this study, the effect of *Crataegus pseudomelanicarpa* (humid areas, northern Iran), *Onobrychis cornuta*, *Berberis integerrima* and *Juniperus sabina* (sub alpine areas, northern Iran) and, *Astragalus myriacanthus* and *Acantholimon spinosum* (semi-arid areas, central Iran) on SSB characteristics was studied. Soil samples were collected under the canopy of shrubs and the control (out of canopies) from 0-5 cm and 5-10 cm depths by auger and seed germination was monitored in the greenhouse. The results showed that generally all shrub species in different climates had a significant positive influence on SSB density and diversity in all climates. In comparison between subalpine shrubs, density of the SSB was lowest under *J. sabina* and highest in the control area, but did not differ between *B. integerrima* and *O. cornuta*. In comparison between semi-arid shrubs, the mean density of SSBs under *A. myriacanthus* (904 seeds/m^2) was significantly higher than that of *A. spinosum* (361 seeds/m^2). This study revealed that the extent to which vegetation affected SSB characteristics depends on the presence and species of shrubs in the area.

Introduction

The soil seed bank (SSB) is one of the most important functional parts of each plant community, which by storing seeds in the soil, maintains the populations of each plant community in case of natural or human degradation (Thompson, 2000). The SSB is a memory that stores the changes in each region, reflecting the history of management, and may play an important role in the succession of plant communities, protecting them, and conserving genetic diversity (Thompson, 2000). The relationship between plants and their interactions within a plant community is one of the important factors determining the speed and direction of the succession process (Myster, 2004). The theories of plant communities are founded on the widespread understanding of these positive and negative interactions between plants, including the facilitating process (Bertness and Callaway, 1994). Facilitation is known as an important process in the development of the diversity and composition of plant communities (Hupp et al., 2017). The main mechanism of facilitation is improving and modifying environmental conditions under the crown cover, reducing environmental stresses, creating appropriate microhabitats and growth of other species (Erfanzadeh et al., 2014). Facilitating plants are called nurse plants, often shrubs that have a short and compact form (Chen et al., 2017). Nurse plants often improve the tough, stressful environmental conditions in a way that increases the diversity of species (Falster et al., 2018). It is well known that in the microclimatic facilitation, nurse plants balance the humidity, light, and temperature, improve organic and mineral materials, and increase the available resources under the plant and fertility under their crown cover; thereby, other plants grow and settle under their canopies (Filazzola & Lortie, 2014). In facilitation processes, shrubs as nurse plants protect herbaceous plants under their canopies against grazing, weaken some environmental factors such as direct sunlight, trap sediments and provide shade and shelter against the wind and subsequently change the SSB characteristics depending on the shrub species and the climate condition (Anthelme et al., 2017). In this study, the effects of different shrub species on SSB charactersitics were studied in different climates in Iran. We hypothesised that the effect of shrubs on SSB is positive, enhancing SSB density and richness.

Methods and study sites

Three different locations were selected in different parts of Iran. In each location, the dominant shrub species were selected for the study:

1) Northern Iran with a humid condition in which *Crataegus pseudomelanicarpa* M. Pop. ex A. Pojark (Rosaceae family) was the dominant tree in the ecotone between forest and grassland. Fifteen individuals of *C. pseudomelanicarpa* were randomly selected in grazed and ungrazed areas (10 in grazed and 5 in ungrazed areas).

2) Northern Iran with subalpine conditions in which three shrub species were considered. I) *Berberis integerrima* Bunge (family Berberidaceae), also known as common barberry, is an upright deciduous shrub with an average 1.8 m tall in the study area. The canopy structure is open with thorny branches. II) *Juniperus sabina* L. (family Cupressaceae), commonly known as savin juniper, is a shrubby evergreen dwarf conifer that is native to mountain areas. It is usually seen as a wide-spreading shrub to an average of 90 cm tall in the study area. The canopy structure is low stature and procumbent with uncompact form. III) *Onobrychis cornuta* (L.) Desv. (family Fabaceae), commonly known as Holy clover, perennial, deciduous, branched spiny shrub, forming cushions or tufts, up to 60 cm in height in the study area. The canopy structure is low stature with dense compact form. We selected ten sites as ten replications in which all three different species were found closed to each other in each site.

3) Central Iran with dry and semi-dry conditions in which two different shrub spcies were selectes. I) *Astragalus myriacanthus* is a perennial plant, shrubby, cushion, branched, non-palatable and prickly, with a height of 30-80 cm and a crown diameter of 50-100 cm, covered with white fuzz and belongs to the Fabaceae family. This species has a raised crown with empty spaces located above the ground (Mozafarian, 2012). II) *Acantholimon spinosum* is a perennial plant, shrubby, cushion, non-palatable and prickly with a height of 20-50 cm, belonging to the Plumbaginaceae family. This species basically grows in the middle elevations on the slopes and sometimes on rocks (Mozafarian, 2012). We selected 10 individuals from each shrub species.

Soil samples were collected under the shrub canopy and outside the canopies from 0-5 cm and 5-10 cm depths. Each soil sample was spread over 3 cm of sterilized potting soil and sand (1:1) in free draining plastic trays of 25 cm × 35 cm in the greenhouse. All trays were kept under natural light and temperature conditions and moist by artificial watering (Niknam et al. 2018). Germinated seedlings were identified, counted and removed once they reached an identifiable stage during greenhouse study (details in Erfanzadeh et al. 2014).

Results

C. pseudomelanicarpa had a significant effect on soil seed bank density and richness (Table 1). The SSB density significantly varied between under-canopy and outside with highest number under canopy and between grazed and ungrazed areas with highest number in ungrazed area. In addition, the effect of shrub-grazing interaction on SSB density was significant (Table 1). Species richness of SSB was significantly different between the two depths and between grazed and ungrazed areas.

Table 1. The effects of *C. pseudomelanicarpa* canopy together with grazing and depth on soil seed bank density and richness in humid Northern Iran.

Source	Log_{10} Seed density (seeds per m2)			Richness		
	Sig.	F	df	Sig.	F	df
Grazing	**0.00**	21.35	1	**0.00**	34.32	1
C. pseudomelanicarpa canopy	**0.01**	3.49	1	0.18	1.82	1
Depth	**0.00**	43.99	1	**0.00**	73.31	1
Grazing × *C. pseudomelanicarpa* canopy	**0.00**	14.46	1	**0.00**	25.17	1
Grazing × Depth	0.79	0.06	1	0.83	0.04	1
C. pseudomelanicarpa canopy × Depth	9.38	0.01	1	0.49	0.47	1
Grazing × Patch × Depth	0.38	0.76	1	0.69	0.15	1

In subalpine northern Iran, the results showed that SSB density in the upper soil layer (0-5 cm) was lowest under *J. sabina* (2,507 seeds per m^2) and highest under the two other woody species In the lower soil layer, seed bank density was highest under *B. integerrima* (2823 seeds per m^2) and lowest under the other two shrubs patches (Fig. 1 and Table 2). The SSB richness showed significant differences in lower soil layer with highest in *B. integerrima* with no significant differences in under-shrubs in the upper soil layer.

Table 2. The results of the effect of three shrubs and depth on soil seed bank density and richness (One-way ANOVA) in subalpine northern Iran. The shrubs are *Berberis integerrima*, *Juniperus sabina* and *Onobrychis cornuta* together with the control.

Soil seed bank parameters	Depth	*Df*	*F*	*p*-value
	0-5 cm	3	3.822	0.02
Density	5-10 cm	3	1.805	0.16
	0-5 cm	3	0.897	0.46
Richness	5-10 cm	3	3.479	0.03

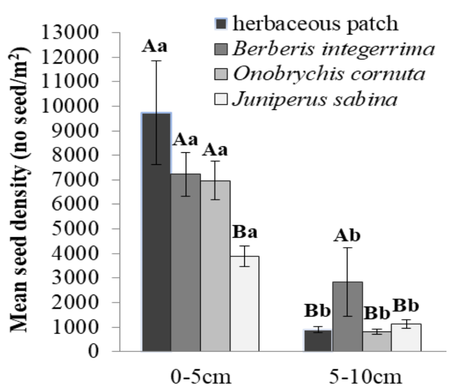

Fig. 1. Average of soil seed bank density (±SE) under the three shrub species, subalpine northern Iran. Small successive letters indicate significant differences between two depths (0–5 cm and 5–10 cm) per shrub and capital letters indicate significant differences between shrubs (0–5 cm, 5–10 cm and 0-10 cm) per depth.

In dry central Iran, the results showed that the main effects of the shrub on SSB density was significant. Differences in the type of shrub plant species led to a difference in SSB density so that the mean density of SSBs in *A. myriacanthus* (871 seeds/m^2) was significantly higher than that of *A. spinosum* (367 seeds/m^2). In addition, the results showed that the main effect of shrub on SSB richness was significant. The results showed that the differences in the type of shrub species did not affect the mean SSB richness and, the mean richness of SSB under *A. myriacanthus* (1.03) was similar to that of *A. spinosum* (1.19).

Discussion

Generally, shrubs in a background of herbaceous species increased SSB density and richness in this study and the previous studies (e.g. Niknam et al. 2017). These shrubs accumulated large and diverse SSBs beneath their canopy, leading to enhance seed density and richness in soil. This accumulation is due to a very high amount of seed input by seed trapping and producing within patch. Indeed, woody patches has a capability in trapping of seeds from surrounding area and increasing seed production by plant species growing within patches (Braz et al. 2014; Tessema et al. 2017). Seeds, transported by wind and water, could be trapped in soil surface beneath shrubby patches and penetrate into soil (Bullock and May 2004). In addition, suitable conditions beneath the patches facilitate colonization and growing of herbaceous species and increase seed production by these species. However, our results showed that the increasing of SSB density and richness were not occurred beneath all shrubs. For instance, among the three shrubs in subalpine areas, *B. integerrima* increased SSB density and richness in 5-10 cm depth compared with bare surrounding area. While O. *cornuta* and *J. sabina* had no significant effect and decreased significantly SSB density, respectively. We believe that the erect and open canopy in *B. integerrima* could give an opportunity to herbaceous species for growing and producing seeds in the empty spaces within the patches. Conversely, the canopy of O. *cornuta* is very dense, compact and clinging to the ground. Therefore, it might be very hard to enter transported seeds (by wind and water) into the woody canopy. Moreover, herbaceous species need empty gaps to germinate, vegetative growth and seed producing, while these gaps are absent within the canopy. As a results, seed density and richness beneath O. *cornuta* could become equal or even less than outside the patches.

This study revealed that the extent to which vegetation affected SSB parameters was not only depend on the presence of shrubs, but also on the type of shrub species in the grasslands and the type of climate. Particularly, changes in the type of shrub species can significantly vary the proportion of SSB density in the natural grasslands that should be considered in conservation projects in the degraded areas.

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