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# THE SOIL SEED BANK PATTERN IN HIGHLAND RANGELANDS OF EASTERN ANATOLIAN REGION OF TURKEY UNDER DIFFERENT GRAZING SYSTEMS

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**ABSTRACT**

**Soil seed bank dynamics are crucially important for natural recovery of degraded ecosystems. The study was conducted on the natural rangelands applied different grazing system at Kargapazari Mountain in Erzurum, Turkey and was aimed to explain the role of applied different grazing system and soil properties on the abundance and spatial distribution of plant species in the seed bank. Total 73 taxa were recorded, 22 of them were annual species on the experimental area. The species number in the seed bank changed between 26 and 36 among the sites. The winter grazing system (WGS) sites had the highest species richness while spring grazing system (SGS) sites had the lower species richness. The highest perennial grasses seedlings were recorded for spring-autumn grazing system (SAGS) and season-long grazing system (SLGS) sites than the others. Similar differences were also recorded for the other functional groups and common species among the range sites. The differences in spatial distribution of plant species in the seed banks were mainly addressed geomorphological heterogeneity rather than grazing system effect while the differences in seed bank composition among range sites were mainly addressed in the difference of grazing season and pressure originated from grazing system practices. The effects of grazing system practices and soil properties on seed bank composition were clearly explained with Redundancy Analysis (RDA). However, there were great differences in seed bank composition among the range sites and virtually all sites have enough seed stock for natural recovery but current grazing system practices should be improved in favour of increasing seed scattering of desired plants in the experimental area and similar steppe rangelands.**

**Keywords: Highland rangelands, seed banks, seed bank and environmental relations, spatial distribution, species richness and abundance**

## INTRODUCTION

Seed banks and their role in the sustainability of grazing ecosystem have been the subject of much recent debate. Two processes, first the vegetative spread of plant species and second the determining of seedlings from the seed bank, are important in determining the species composition of a plant community (Peco et al., 1998). Rangeland plant community responses to ungulate grazing may be affected by management practices. Therefore, grazing treatments are important tools for sustainable usage of grazing ecosystems. The history of grazing, which has been a major factor in determining the structure and organization of plant communities in ecosystems, is as old as human history (Sternberg et al., 2003). The resilience of plant species to grazing is dependent upon environmental factors, animal behaviours and the soil seed bank. The potential for restoring species-rich rangelands and maintaining floristic diversity are the major factors that have motivated researchers to compare the composition of the surface vegetation with seed reserves in the soil (Wilems, 1983; Mc Donald et al., 1996).

Grazing reduces the seed production of perennial species due to the reduction of photosynthetic tissue and the removal of flowers and seeds stalks (Sternberg et al., 2003; Bakoglu et al., 2009). Grazed species generally have less seed production ability because grazing encourages vegetative reproduction over sexual reproduction (Sternberg et al., 2003). In addition, seeds produced by grazed plants have a short-term persistence in the soil (Champness and Morris, 1948; Peco et al., 1998; Sternberg et al., 2003). Over grazing may firstly lead to reduce seed production of the palatable species (O'Connor and Pickett, 1992). However, it is not clear whether or not grazing alone can deplete the seed bank of perennial species, causing long-lasting negative effects on the biological diversity and production potential of rangelands. Annual species are more persistent to extreme climatic conditions and grazing than perennial species

(Erkovan, 2000), because they produce and scatter a high amount of seed under favourable years and the seeds live in the soil for several years.

Environmental factors have been shown the influence in the structure and function of rangelands in the East Anatolia region, which are usually dominated by perennial grass species that are more persistent to the climatic extremes and grazing (Koc, 1995; Erkovan, 2000; Koc, 2001; Gullap, 2010). Grazing animals have three main effects on rangeland vegetation diversity and structure such as the removal of plant tissue, compaction of the soil by trampling and altering competition among plants (Gokkus and Koc, 2001; Holechek et al., 2004). In Eastern Anatolia traditional grazing practice are started as soon as snow melts in the spring and continues up until snow covers the ground in the winter (Koc and Gokkus, 1998). These effects seriously restrict seed production in plants (Hickman et al., 2004). The effect of grazing on seed production is changed depending on the system taking the place of grazing. While active growing season grazing on the rangeland results in decreasing seed production of palatable plants (Hopkins et al., 2003) dormant season grazing results in flavour of palatable plants with respect to seed production (Menke, 1992). Sternberg et al. (2003) reported that increased grazing intensity leads to a serious decrease in the contribution of palatable plants in the seed bank. Similar results were also reported by Kinucan and Smeins (1992) and Bakoglu et al. (2009). The season of grazing alters seed bank density and diversity. Dormant season grazing may cause a less detrimental effect on seed production and the scattering of palatable species. Therefore, the seed bank of the area grazed during the dormant season has more palatable species seeds in the seed bank than that of the area grazed during the growing season (Gokkus and Koc, 2001).

Recently, seed banks have received considerable attention in relation to the conservation, management and restoration of natural ecosystems because soil seed banks are the important components of vegetation dynamics and resilience (Bertiller and Aloia, 1997). Restoration of degraded rangelands requires more labour and cost, conversely, the return of cost takes a long time and never establishes ex-biodiversity (Anonymous, 2008). Grazing as a component of environmental factors can change the vegetation composition such as diversity and density of species (Bullock et al., 1994; Bertiller and Aloia, 1997).

Seed banks have an effective stabilising mechanism in the maintenance of productivity and diversity in rangeland ecosystems. There have been some studies related to seed banks in the other grazing ecosystems although few studies have been conducted in steppe or high altitude grazing ecosystems (Peco et al. 1998). The objectives of our research were to evaluate (1) the role of grazing conducted in different grazing systems on the abundance of plant species in the seed bank (2) the role of the seed bank on natural restoration in highlands changing the different grazing systems (3) the contribution of the different grazing systems on vegetation patterns (4) to explain interactions among seed banks and the other environmental variables.

## MATERIALS AND METHODS

### *Study area*

This study was conducted at the Kargapazarı Mountains in Erzurum province located in the Eastern Anatolia Region of Turkey. Four different grazing systems with two locations were selected to compare the effects of grazing practices on seed banks. In the experimental area, the elevation changed between 1900 and 2500 m among the sites. Grazing systems can be summarized as follows: (1) Season-Long Grazing System (SLGS): the sites are located at $40^{0}18^{I}78^{II}$ N, $41^{0}19^{I}08^{II}$ E, an altitude of 2340 m, and $40^{0}16^{I}12^{II}$ N, $41^{0}23^{I}43^{II}$ E, an altitude of 2210 m. These sites are grazed from the beginning of spring to the beginning of winter or until snow cover and also used as a lowland part of the transhumant grazing system. (2) Spring and Autumn Grazing System (SAGS): the sites are located at $40^{0}22^{I}97^{II}$ N, $41^{0}25^{I}40^{II}$ E, an altitude of 1950 m, and $41^{0}25^{I}40^{II}$ N, $41^{0}23^{I}83^{II}$ E, an altitude of 2000 m. These sites are grazed firstly from spring to the middle of the growing season (around the middle of June) and grazed until after the middle of September until the beginning of November. (3) Summer Grazing System (SGS): The sites are located $40^{0}21^{I}20^{II}$ N, $41^{0}24^{I}39^{II}$ E, an altitude of 2100 m, and $40^{0}25^{I}51^{II}$ N, $41^{0}19^{I}79^{II}$ E, an altitude of 2440 m. These sites are grazed from the middle of June to the middle of September and also used as upland part of the transhumant grazing system. (4) Winter Grazing System (WGS): the sites are located at $40^{0}25^{I}68^{II}$ N, $41^{0}20^{I}60^{II}$ E, an altitude of 2350 m, and $40^{0}17^{I}73^{II}$ N, $41^{0}21^{I}14^{II}$ E, an altitude of 1910 m. These sites are grazed initially in the first half of the growing season and closed to grazing until winter and re-opened to grazing at the beginning of winter and continue up until snow covers the ground. WGS and SAGS areas are generally located on the south aspect of the mountain and grazed mainly by sheep, whereas sheep and cattle graze the other areas where having rough topography. Kargapazarı Mountains is characterized by harsh climatic conditions with a long and extremely cold winter and a cool, short and dry summer. The nearest meteorological station to the study sites is located in Erzurum city, located at 1850 m, according to the records of the station, the long-term average annual temperature is 6 $^{o}$C, the average total annual precipitation is 450 mm, falling from late autumn until the beginning of summer and relative humidity is 63%. The growing season of the vegetation is closely associated with the melting of snow and ceased by dry conditions prevailing in the beginning of August and thereafter seed scattering occurs in the plants.

The soil texture was loamy in the SLGS and SAGS site, clay-loam in the SGS site and sandy-loam at the WGS sites. Soil pH was neutral in the SLGS, SAGS and WGS, although it was slightly acidic in SGS. Soil organic matter content changed between 3.9 and 5.8% among sites. The study sites soils were rich in the corresponding available K, although they were insufficient with respect to Olsen P content.

Major components of botanical composition of the sites are characterised as *Agropyron intermedium, Bromus tomentellus, Festuca ovina, Koeleria cristata* as grasses, *Medicago varia* as legumes and *Convolvulus arvensis, Potentilla recta, Herniaria incana, Minuartia anatolica and Rumex acetosella* as forbs species.

*Experimental design and sampling*

In all sites, a central point was chosen for taking samples, thereafter 5 transect lines, each of which is 90 m in length, with 20 m interval were established towards the south to north direction. Nine soil cores were taken from a 10 m interval on every transect line and a total 45 soil cores were collected at each site.

Seed bank sampling was performed as the following the procedure described by Pugnaire and Lazaro (2000). Soil cores were collected in late August 2008 before the autumn rains, which onset the germination of seeds in the seed bank because summer dormancy occurs every year at this time (Bakoglu et al., 2009). Forty five soil cores in a diameter of 10 cm were sampled, as described by design in the preceding paragraph, to a depth of 6 cm from each sample put into a cloth-bag after the removal of gravel, litter and roots. All samples were air-dried and stored in the dark up to the beginning of March 2009 at 4 $^0$C. Seed banks were determined using a germination method commonly used for field surveys of soil seed banks (Pugnaire and Lazaro, 2000). To germinate seeds in seed banks, the soil cores were spread into a plastic tray (25 cm diameter and 6 cm deep) to a depth of approximately 2 cm. The trays were placed in a greenhouse under semi-controlled conditions and under natural light, and the temperature ranged from between 15 and 30 °C. The trays were watered once or twice daily with tap water to keep the surface moist during the 90 day experimental period (Sternberg et al., 2003). As seedlings emerged, they were identified and counted as soon as possible and removed from the tray. For meter square, the number and composition of soil seed banks were calculated using the number of emerged seedlings and the results were presented for seedling size and number and percentage of vegetation composition.

Square root transformation were applied to data of all functional groups abundance to meet the assumptions of ANOVA based on general linear models in a Completely Randomized Design using the Statview statistical package (SAS Institute, 1998). Since data were homogeneous between the locations, data for locations were combined in the variance of analysis (Petersen, 1994). The results were given overall of location since there were no significant differences between location and also significant interaction with location. Means were separated using Duncan’s Multiple Range Test (Steel and Torrie, 1997).

*Spatial distribution of the soil seed bank*

Punctual kriging analyses were performed for the distribution patterns of spatial variability of seed banks in the grazing systems using the GS + geostatistical software (Gamma Design Software, 2005). The best fit models were chosen by considering the minimum RSS (residual sum of squares) and maximum $r^2$. The RSS is generally preferred due to the long distance among samples (Aksakal and Oztas, 2010).

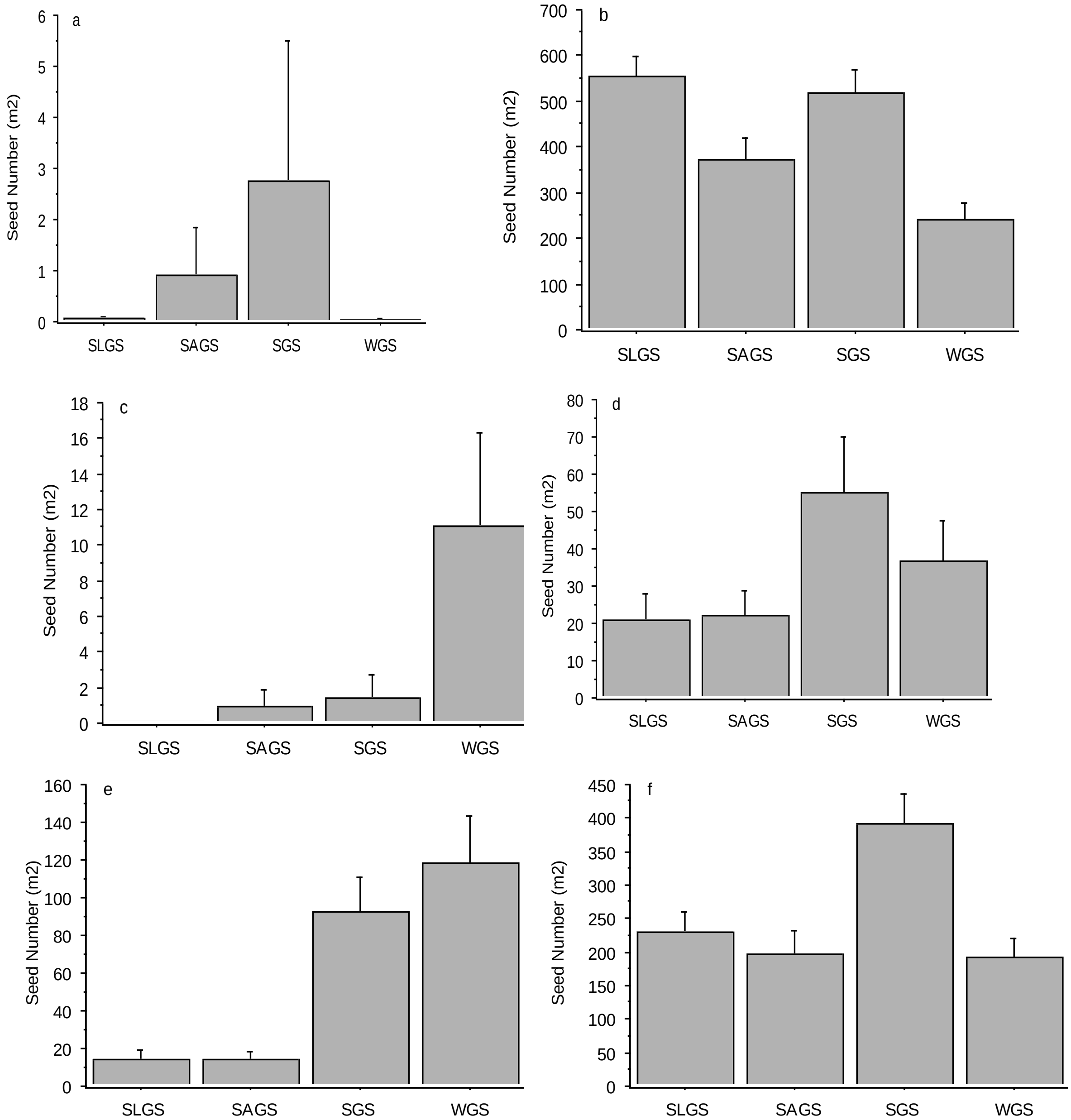
*The relationships between the soil seed bank and environmental properties*

The effects of grazing systems, the soil seed bank and soil properties on the seed banks of the rangelands were tested. The ordination analysis was performed in order to provide insights into the effects of grazing systems and soil variables on the species coexisted in seed banks of all sites, using the program CANOCO, version 4.5 (ter Braak and Smilauer, 2002). Ordination involved two steps: indirect gradient analysis (unconstrained ordination) and direct gradient analysis (constrained ordination). Indirect gradient analysis was used initially to search for major gradients in the plant species data, irrespective of independent variables. Direct gradient analysis was then used to explain the vegetation data in terms of specific explanatory variables of interest (e.g. disturbance-related and environmental variables). The relationship between the seed banks and environmental factors was determined with linear method (redundancy analysis) RDA since length of gradient was over 4 in the analysis. The RDA was used to combine four grazing systems with plant species, seed numbers and soil properties. According to the RDA results, environment variables, seed numbers and occurred species were used to ordinate sites. Therefore, the RDA occurred from 10 species and environmental variables (soils). A three-plot of the RDA shows the correlation among species composition and environment variables by the direction and length from the centroid of the ordination scores. Species data was transformed because the seed number insisted on many zeros using the transformation ln (10 X x + 1), where X = species number in the seed bank. Automatic selection was used to determine the variance explained by individual variables. Monte Carlo permutation tests were used to test the significance of each variable.

## RESULTS

*Richness and abundance in the soil seed bank*

A total 73 taxa were recorded, 51 of which were perennial, over the whole experimental area and the species number were 33 in SLGS, 30 in SAGS, 28 in SGS and 36 in WGS (Table 1). Annual species number changed between 4 and 10 among the sites while perennial species number changed between 18 and 29 among the sites. Annual grasses abundance was extremely low on the experimental area. SGS and SAGS areas had 2.8 and 0.9 seedlings per $m^2$ while the other sites had no annual grasses (Figure 1a). Perennial grasses abundance changed significantly ($p < 0.01$) among the sites. The highest perennial grasses seedling number was recorded in SLGS and SGS sites and the lowest was recorded in WGS sites (Figure 1b). Annual legumes seedlings number changed significantly ($p < 0.05$) and the highest annual legumes



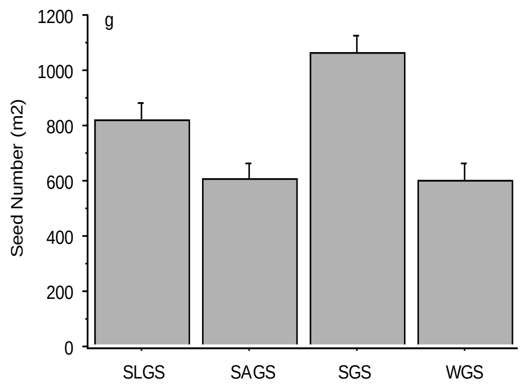




**Figure 1.** The effects of seed density of functional groups. Annual grasses (a; p<0.4281), Perennial grasses (b; p<0.0001), Annual legumes (c; p<0.0421), perennial legumes (d; p<0.0840), Annual the other families (e; p<0.0001), perennial the other families (f; p<0.0003) and Total (g; p<0.0001).

seedling number was recorded in WGS among the sites (Figure 1c). There were no annual legume seed in the seed bank of SLGS sites and it was 2.8 and 0.9 seedlings per $m^2$ in SAGS and SGS sites, respectively. Perennial legumes seedlings number was the highest in SGS (55.1 $m^{-2}$), medium in WGS (36.8 $m^{-2}$) and the lowest in SLGS (20.7 $m^{-2}$) and SAGS (22.0 $m^{-2}$) sites (Figure 1d).

**Table 1.** Species richness among the range sites.

| Sites | Annual | Perennial | Total |
|---|---|---|---|
| **SLGS** | 4 | 29 | 33 |
| **SAGS** | 6 | 24 | 30 |
| **SGS** | 10 | 18 | 28 |
| **WGS** | 9 | 27 | 36 |
| **All Area** | 22 | 51 | 73 |

Annual species seedlings number of the other families changed significantly among the sites ($p < 0.01$). The abundance of annual species belong to the other families were highest in WGS ant the lowest in SLGS and SAGS sites (Figure 1e). Perennial species seedlings abundance of the other families was the highest in SGS (391.3 $m^{-2}$) and it was the lowest in WGS (191.1 $m^{-2}$). The seedling number was also lower in SLGS and SAGS and their seedling numbers were statistically similar to WGS sites (Figure 1f). Seedling numbers per $m^2$ changed significantly among the sites. SGS had the highest seedling number (1060.8) while WGS had the lowest seedling number (599.4) (Figure 1g).

*Spatial distribution patterns of the soil seed bank*

The experimental semi-variograms showed no distinct differences among the structures of semi-variogram models, which was fitted for characterising spatial variability in the abundance of the seed bank under different grazing systems. The best-fit models and model parameters are presented in Table 2. The range of influence was determined to be between 12.2 m and 128.9 m in different rangeland types (Table 2). According to the results, the degree of homogeneity in the rangeland types was the highest in the WGS. The distribution pattern of the seed number showed important differences among rangeland types (Figure 2a-d). Seed number dispersion had a patchy distribution pattern on the ground in the SLGS and SGS (Figure 2a,c). The seed number increased from south to north and from west to east in the winter rangelands, whereas it showed opposite distribution in the west to east direction, while it was similar in the south to north direction in the SAGS (Figure 2b,d).

**Table 2.** The best-fitted semi-variogram models and model parameters for the seed number of species in the different grazing systems

| | Best-Fit Model | Nugget ($C_0$) | Sill ($C+C_0$) | Range of Influence ($A_0$) | $r^2$ | RSS |
|---|---|---|---|---|---|---|
| **SLGS** | Spherical | 9500 | 203200 | 14,30 | 0.489 | 4.58E+08 |
| **SAGS** | Gaussian | 91600 | 217700 | 40.20 | 0.860 | 9.66E+08 |
| **SGS** | Spherical | 100 | 192500 | 12.20 | 0.123 | 4.27E+08 |
| **WGS** | Spherical | 78500 | 329800 | 128.90 | 0.784 | 2.30E+09 |

*The relationships between the soil seed bank and Environmental Variables*

The results of the RDA showed that species distribution in the seed bank partly revealed that clustering depends on the rangeland types (Figure 3). The distribution pattern of species on canonical axis was significant ($P < 0.002$) and the species of every site generally congregated around the same places on the axes. The result of the RDA showed that the four axes explained 41.9, 71.9, 86.6 and 91.9 % of the cumulative variance of species-environment relation, respectively (Figure 3). The species belonging to WGS mostly positioned on right upper quarter, while the SAGS and SLGS species positioned on left down quarter, the SGS species positioned on left upper quarter (Figure 3). While *Bromus tomentellus, Rumex acetosella* and *Medicago varia* were common in the seed bank of the WGS, *Festuca ovina* were common on SLGS and SAGS sites' seed stocks. *Minuartia hirsuta, Koeleria cristata* and *Herniaria incana* were common in SGS sites. WGS sites had greater phosphorus content in soil samples and it was positively correlated ($r^2$= 0.667) with *M. varia, R. acetosella* and *B. tomentellus*. Whereas, SGS sites soils were greater in organic matter and potassium content than the other sites and they were positively correlated ($r^2$= 0.589) with *M. hirsuta* while SLGS and SAGS sites had greater calcium content in the soil than the other sites and air permeability of the soil were positively correlated ($r^2$= 0.415) with *F. ovina* abundance in the seed bank.

## DISCUSSION

Herbivores, affecting on the plant community either directly or indirectly, are a crucial part of the grazing ecosystem. There were significant differences with respect to seed bank composition among range sites grazed for a different period in the study because number of coexisting species was only 10 out of 73 in all sites. These results strongly indicated that the period of grazing that occurred in the season is the most important factor for seed bank composition. Nevertheless, these differences cannot be attributed solely to grazing application because of besides grazing. There were considerable differences in soil properties and topography especially between WGS and the others. As mentioned by Peco et al. (1998), so many

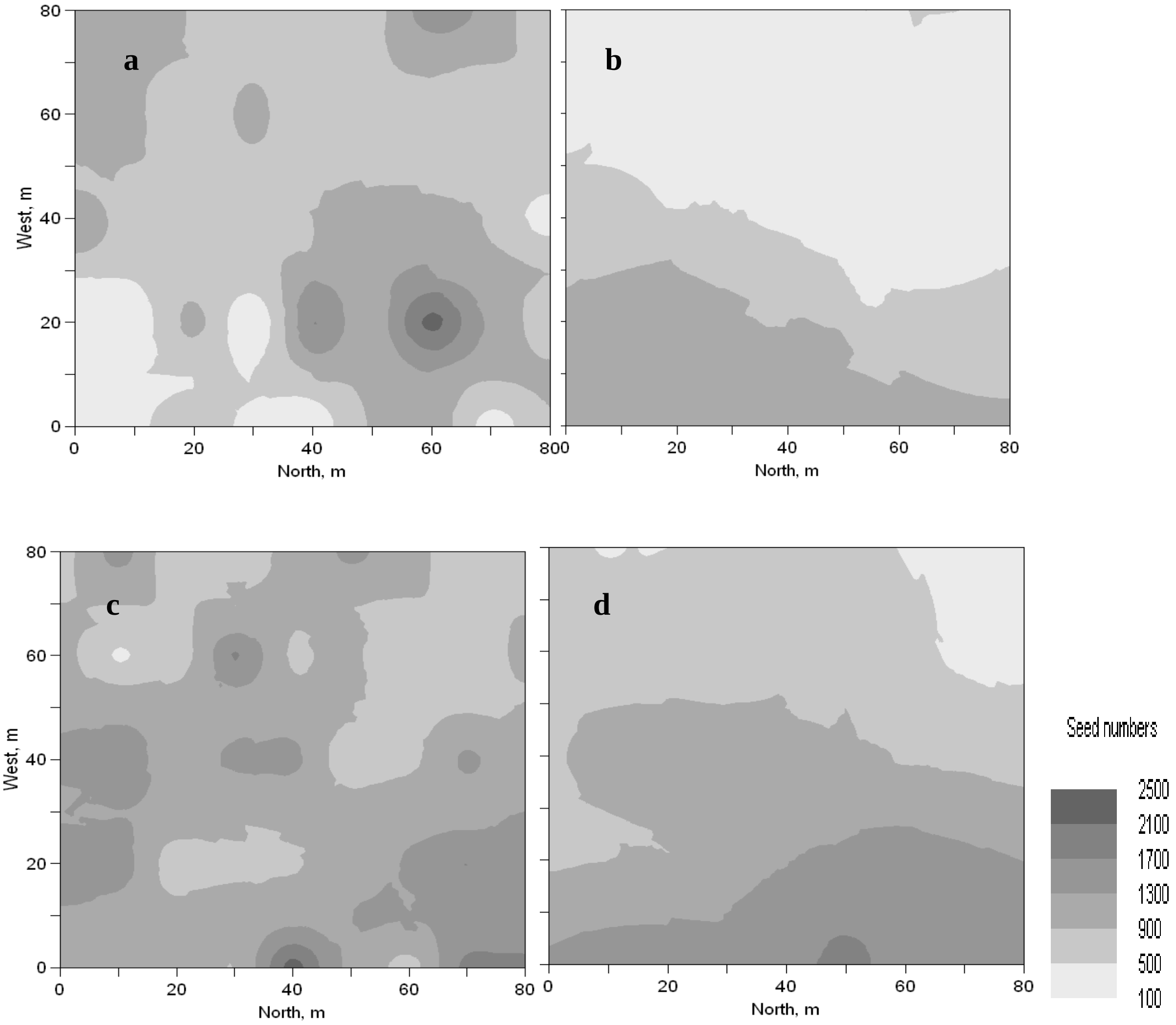



**Figure 2.** Distribution patterns of the seed numbers in the different grazing systems ((a) SLGS, (b) SAGS, (c) SGS, (d) WGS).

environmental factors affect on seed bank density and composition. The sites subjected to growing season grazing (SLGS and SAGS) had lower annual species number than the other sites. This situation was probably originated by uncontrolled grazing during active growing season for decades in the sites because young seedlings of annuals can be preferred by herbivores and seed scattering of these plants decrease year by year due to grazing (Sternberg et al., 2003).

The seed banks of the experimental area had a high proportion of germinable grasses seeds. The study area climate is characterised by frequent light rains during the spring and early summer with only the upper layer of the soil moist and favours grasses over other plants because the shallow and fibrous roots of grasses use soil surface moisture more efficiently than the coarse roots of plants do (Holechek et al., 2004). Therefore, grasses abundance was high in the experimental area. Similar results were also reported by other researchers (Pagnotta et al., 1997; Sternberg et al., 2003).

There were great differences among rangeland sites with respect to composition of the seed bank in the experimental area. The lowest grasses seed density was recorded at the SAGS. The reason for this result might be related to the grazing time because the areas are grazed from early spring to beginning of summer and beginning of autumn to beginning of winter. All grass species in the experimental area were cool season grasses, which grow earlier than the other species, and they are the main food resource for grazing animals. Cool season grasses cannot produce seed after their reproductive shoot is grazed in the spring because they require vernalisation for reproductive shoot development, which is not possible during the growing season (Mc Donald et al., 1996; Koc, 2001). Therefore, the lowest grass seed abundance might be related to defoliation by grazing of the reproductive shoot in the areas grazed in autumn and winter (Figure 1a). Cool season grasses produce reproductive shoots preceding the autumn (Serin et al., 1999; Koc, 2001) and some of them grow up on the ground depending on moisture availability while the others stay at primordial buds. As early developed reproductive shoots grazed during the winter grazing period following years grow up only primordial buds. As a result of this situation, the seed abundance of grasses in the seed bank were higher in the SGS and SLGS sites than the other sites.

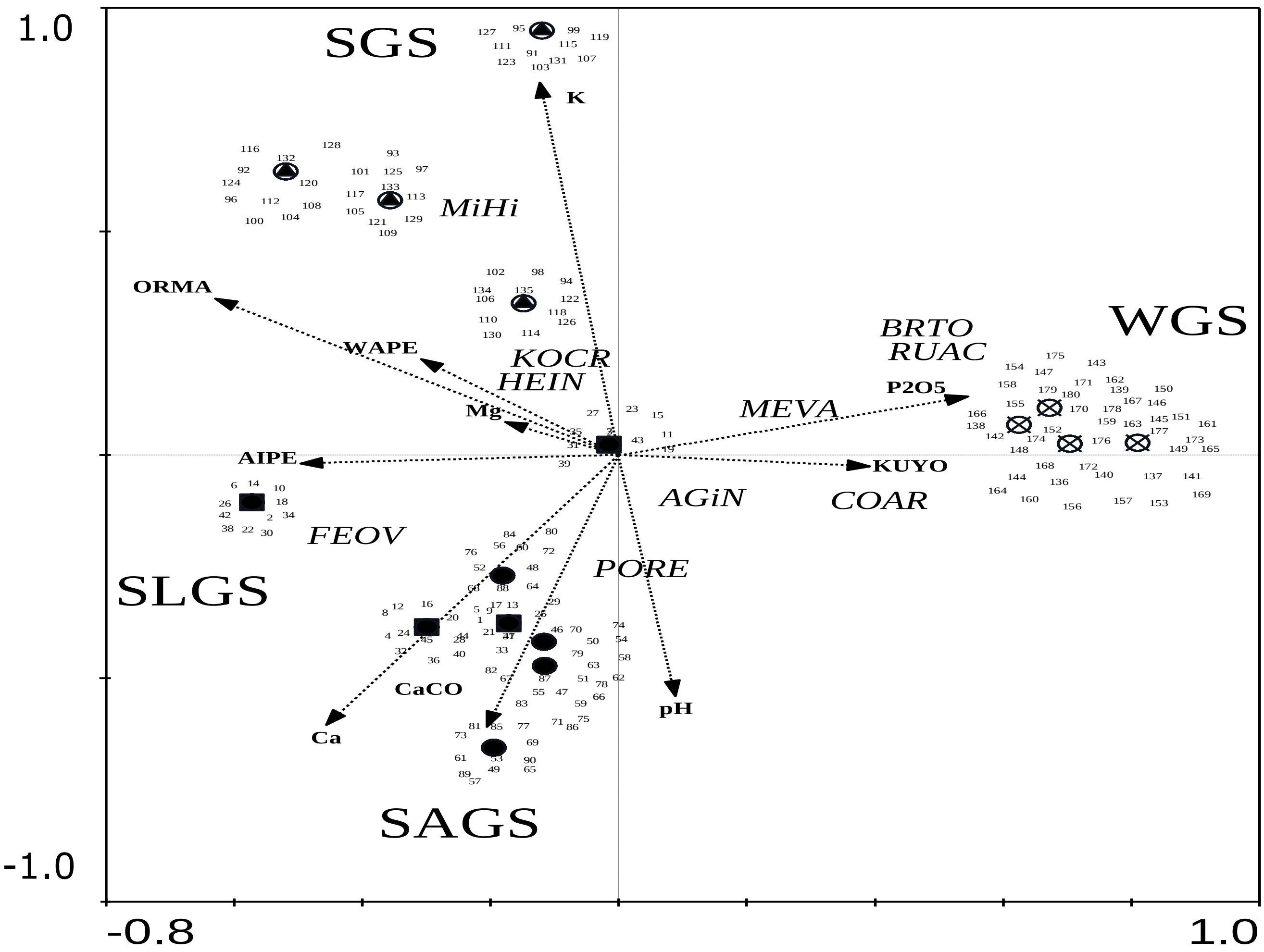



**Figure 3.** Redundancy Analysis with environmental (soil) variables is a significant proportion of the variability of the seed number in the different grazing season. (Filled square and circle represent SLGS and SAGS respectively, Filled triangles represent SGS, Filled cross represent WGS). The codes of the species name are AGIN *(Agropyron intermedium),* BRTO *(Bromus tomentellus),* COAR *(Convolvulus arvensis),* FEOV *(Festuca ovina),* HEIN *(Herniaria incana),* KOCR *(Koeleria cristata),* MEVA *(Medicago varia),* MIHI *(Minuartia hirsuta),* RUAC *(Rumex acetosella),* PORE *(Potentilla recta),* ORMA (Organic matter), AIPE (Air permeability), WAPE (Water permeability), KUYO (Bulk density), CaCO (Lime), pH (pH), P2O5 (Phosphorus), Ca (Calcium), Mg (Magnesium), K (Potassium), SLGS (Season-Long Grazing System), SAGS (Spring and Autumn Grazing System), SGS (Summer Grazing System, WGS (Winter Grazing System).

In as much as grazing intensity, the grazing season affects on the seed bank composition and structure in the rangelands (Seligman, 1996). The variability in abundance and richness of the other families in the seed bank among rangeland sites might be attributed to seasonal differences in the grazing in the experimental area. Because these species could have not been preferred by domestic herbivores and they take competition advantage under grazing, thus, they produce more seed in line with increasing in the adverse effect of grazing. Our findings strongly supported the idea that the season of grazing is the most effective factor on seed bank composition under similar grazing pressures.

Spatial heterogeneity in the rangelands vegetation is determined by different environmental factors such as soil properties, climatic (Janssens et al., 1998) and grazing intensity (Sternberg et al., 2003) and season (Peco et al., 1998). Depending on the environmental factors, plant composition may change sharply at short distance either favourably or unfavourably. The heterogeneity in seed bank composition and their spatial distribution cannot attribute to grazing solely; in addition, the landscape might also contribute in this heterogeneity because every rangeland type had different landscape properties in the experiment. Conversely, the response of plant species to grazing and grazing systems is different and these differences cause patchy composition on natural rangelands. Grazing intensity and grazing period also effect plant composition and distribution on the rangelands (Wilems, 1983; Sternberg et al., 2003). According to best-fitted semi-variogram model analysis, seed distribution models had high $r^2$ values in the SAGS and WGS (Table 2). According to the seed number in the experimental area, the spatial pattern of the seed bank showed a different distribution between grazing systems in the south-north direction due to differences in environmental factors.

The seed number per area increased from south to north in the SAGS and WGS although there was irregular seed dispersal in the SLGS and SGS. The increases in the seed number per area in the WGS and SAGS might be related to carry out seeds by overland flow depending on slope because these rangeland types are located on the south aspect and the slop increased from the south to north direction. Similar results were reported by Han et al. (2011). Irregular seed distributions in the SLGS and SGS are most probably related to the surface morphology of the areas. Both areas had rugged topography and this morphological feature affects on both grazing and plant distribution due to the changing microclimate (Poesen and Lavee, 1994).

The changes of seed bank composition among sites attribute to the grazing system and soil properties differences were successfully reflected by RDA. The degree causing variation in grazing system and soil properties affects on the seed production capability of standing plants may reflect seed bank composition. In SLGS and SAGS areas, the reason for *F. ovina* abundance might be related to grazing tolerance of the species because this species produce much tiller per bunch and some of them escape grazing (Koc, 2001; Unal et al., 2011). The relationship between abundance of *M. varia* and *B. tomentellus* and WGS might be related to absence of grazing during the active growing period because the area is grazed mainly from late autumn to snow cover. In SGS sites, the higher *K. cristata*, which a decreaser plant for region rangelands (Anonymous, 2008), and higher organic matter content in the soil might be related to grazing season and more dead material turnover in to soil because the plants on this sites did not face grazing pressure during early and late season grazing. In the analysis, although both grazing system and soil properties affect on seed bank composition, there were no extreme soil properties and plant growth restricting was not recorded in the experimental area. Hence, the differences in seed bank composition as well as its spatial distribution in the area can be mainly addressed to the differences in the grazing practice.

The natural restoration of rangelands is a slow process under extreme climatic conditions, however, it is a more environmental friendly restoration processes compared to man made restoration efforts. Therefore, the soil seed bank dynamics are crucially important to natural ecosystems. In this study, although there were great differences in the seed composition in the soil seed bank among rangeland sites, virtually all sites have enough seed stock in the soil seed bank for natural recovery in the region. However, density of undesirable species is quite high, and this situation can be interpreted as revised current grazing practices. In this manner, current grazing practices should be improved in favour of increasing in the seed dispersal of desired plants at regular intervals.

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