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Impact of grazing on soil seed bank replenishment under the Mediterranean climate of northern Syria

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Introduction

Rangelands represent 70% of the semi-arid and arid Mediterranean land mass. It is a habitat for millions of people whose livelihood depends on animal husbandry. The revolutionary developments in the animal husbandry and veterinary medicines resulted in exponential increases in livestock and human populations living on and from dry lands. To respond to population growth, expansion on urbanization, transportation and road networks, land reform and rural development policies forced nomads to adopt sedentary lifestyles. The demographic changes coupled with national and international border crossing restrictions escalated opportunistic cultivation, and excessive exploitation of the scarce and slowly renewable vegetation cover of rangelands (Louhaichi, 2011). In an attempt to stop and reverse the degradation process, large-scale re-vegetation programs based on transplanting and reseeding with perennial shrubs, resting and grazing management systems were devised and implemented (Mosallam, 2007; Mourad *et al*., 2000; Le Houerou, 1981). This study aimed to evaluate the impacts of the rehabilitation programs on the above-ground vegetation cover and soil seed bank replenishment in the Syrian rangelands. The underlying assumption of the rehabilitation program is that with a well-established perennial plant cover and proper grazing management, top soil is stabilized, soil moisture, nutrients and seed bank are replenished, organic matter is accumulated and microorganisms' activity is promoted resulting in greater abundance, species richness and diversity of annuals. To test the above hypothesis, field and controlled environment based studies were carried out with quantitative data collection and processing on plant species abundance, richness and diversity of above-ground vegetation and soil seed bank for fully protected rotationally and continuously grazed areas of 10 rangeland sites in northern Syria for two consecutive seasons based on Russi *et al*., 1992; Magurran, 2004).

Materials and Methods

The study was carried out on 10 rangeland sites in Syria during the autumn of 2006 and 2007 to assess grazing impacts on soil seed bank (SSB) size and composition in arid Mediterranean rangelands under rehabilitation. Nine soil cores of 20 cm diameter and 5 cm depth were collected along grazing gradients in each of the 10 sites. The SSB size and composition were recorded using physical seed extraction and grow out tests methods on 2 and 3 sub-samples of 0.25 and 3 kg soil from each site, respectively.

The number of species (richness) and total number of seed and seedlings for each of them recorded from each soil sample representing grazing treatments within sites (abundance) were used to generate Shannon-Wiener and Simpson reciprocal indices of diversity then subjected to pair wise comparison (Johnson and Kotz, 1969) and *T-test based on* (Magurran, 1988).

Results and Discussion

The soil seed bank data analysis using ANOVA showed, as reported by Kassahun *et al*.(2009), no significant differences in the overall physical and germinable soil seed bank (GSB) size and diversity along the grazing gradient. However, there was a significant grazing-by-site interaction for both and a significant grazing-by-year interaction for GSB size showing that the change in seed bank size is moderated by physical and environmental characteristics and human-induced disturbances. Continuous grazing treatments for some sites were located near human and livestock agglomerations, main roads and water points. Under such conditions the more disturbance-adapted ephemerons and non-palatable plants with limited constraints for seed setting dominated resulting in a larger soil seed bank under continuous compared to rotational and full protection grazing treatments. For the more human-induced disturbance distanced sites, the soil seed bank was larger or similar under full and/or rotational compared to continuous grazing. Non-changing and changing soil seed bank size with degradation gradients have been reported from different habitats (Kassahun *et al*., 2009).

Results from pair-wise comparisons showed a simultaneous decline and surge in physical and germinable soil seed bank size of annuals and those of perennials under the grazing treatments over sites. This suggests relative differences in root competition and gap exploitation characteristics among plant functional groups these differences could be considered indicative to rangeland status and a guide to vary herbivores in order to maintain optimum plant species diversity in the target rangelands.

Physical seed extraction from soil samples collected from continuous grazing resulted in zero soil seed banks size of perennial grasses but grow out test generated 208 seedlings m^{-2}. This is probably due to seed setting failure resulting from overgrazing compensated by vegetative reproduction. The widely used phanerophytes in the rangeland rehabilitation program had a physical soil seed bank size ranging from 59.7 to 119 seed m^{-2} but had a zero germinable one. This shows high complementarity between physical seed extraction and grow out test methods for monitoring rangeland status.

High Morisita-Horn and Sørensen similarities were recorded between the above ground vegetation measurements with each of physical and germinable soil seed banks. However, the similarity indices of the above ground vegetation measurements were higher with the germinable seed bank than with the physical soil seed bank (Tozer *et al*., 2010). This suggests that grow out test is more suitable for monitoring the status of arid Mediterranean rangeland than physical soil seed bank.

Conclusion

Impacts of the grazing management component of the rehabilitation program on the floristic composition of the physical and germinable soil seed bank in the study area is strongly moderated by temporal and spatial variability in the biophysical site characteristics and precipitation. This calls for incorporation of herbivory variation and inter-seasonal rotational grazing into the arid rangeland grazing management calendars.

The simultaneous decline and surge in physical and germinable soil seed bank size of annuals and perennials under the same grazing treatments suggests root competition and gap exploitation among functional groups. Plant species facilitation and association relationship between functional groups moderated by grazing practices is another justification for incorporating herbivore variation to maintain integrity in plant community composition of arid Mediterranean rangelands.

The studies showed a high complementarity of physical seed extraction and grow out test methods for soil seed bank assessment. Grow out test neutralizes the seed extraction associated limitations of over/under estimation of seed bank size by including none germinable seed or excluding vegetative reproduction propagules. The combination revealed the shift in species with different proportional abundance under the different grazing treatments as well as the limitations of germination method for phanerophytes. Nonetheless, the grater species richness captured, simplicity and higher similarity indices of GSB with vegetation measurements makes it a good monitoring tool for species richness and abundance in arid rangelands.

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