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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 9 (3): 465-469, 2006
ISSN 1028-8880

Response of *Stipa lagascae* R. and Sch. to Protection under Arid Condition of Southern Tunisia

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Abstract: The study was carried out at two sites (Menzel Habib and national park of Sidi Toui) of southern Tunisia which provided an aridity gradient to evaluate the effect of long term protection on the regeneration of *Stipa lagascae* R. and Sch., a high range value bunchgrass. In both sites total plant cover as well as density of *S. lagascae* and *Rhanterium suaveolens*, the key species of the arid sandy steppe were determined inside and outside protected areas. Results showed considerable and positive effects of protection on the parameters scored. *S. lagascae* which was very rare in the freely grazed areas is more abundant in the protected areas than *Rhanterium suaveolens*, a chamephytic species. This is an indication that grasses such as *Stipa* are more competitive than chamaephytes for soil water and nutrients when not grazed. When degradation is still reversible, the application of restoration techniques may permit high regeneration of *S. lagascae*.

Key words: *Stipa lagascae*, perennial grass, protection, arid rangelands

INTRODUCTION

In the 1950's cropping was extended and traditional grazing systems (transhumance and nomadism) which had historically allowed for grazing deferment and control of grazing livestock were abandoned (Johnson *et al*., 1992; Le Floc'h *et al*., 1999). Almost all rangelands in presaharan Tunisia (mean annual rainfall 100-200 mm) are now grazed continuously without any restriction on stocking rate. Such changes have led to deterioration in rangeland condition. The degradation of soils and the loss of perennial grasses are two of the direct results of recent aggravations from anthropic pressure on arid rangelands of Tunisia (Chaieb *et al*., 1990).

Grasses are well known by their relatively high palatability. The evidence concerning animal preference is very complex but usually shows that grasses are in general eaten more readily than forbs (Thompson and Uttley, 1982). According to Noy-Meir *et al.* (1989) grasses decrease consistently (decreasers) in response to increased grazing intensity. They consider grasses as plants with attributes that gives them a competitive advantage in competition for space and resources but disfavour them under differential defoliation. These attributes include erect tall shoots, long growing season, perennial life cycles but also palatable and available for grazers. The main negative effect of intensive grazing on perennial grass species is excessive removal of their living parts, which may lead to their extinction.

In North Africa and particularly in Tunisia, the sequences of the plant communities' dynamics are well known (Long, 1954; Le Houerou, 1959; Le Houerou, 1977). It was frequently reported (Le Houerou, 1977; Floret and Pontanier, 1982) that the nearest stages to climax in these zones, were marked by the dominance of perennial grass species. These species such as *Cenchrus ciliaris* L., *Stipagrostis ciliata* Desf., *Digitaria nodosa* Parl., *Stipa lagascae* R. and Sch., are currently rarefied or even extinct in many areas due to cultivation and overgrazing.

Stipa lagascae R. and Sch. is a perennial bunchgrass with an almost circum Mediterranean distribution (Scholz, 1991). It is a grazing tolerant species, but also endangered for extinction (O'Connor, 1996; 1991) due to its heavy grazing by domestic animals. It is a C3 species with high rain use efficiency in cold periods and considered as one of the most promising steppe species for arid land rehabilitation in presaharan Tunisia (Le Floc'h *et al*., 1999; Aronson *et al*., 1993).

The aim of the present study was to evaluate the response of *Stipa lagascae* to continuous sheep and goat grazing compared to protection from grazing in a steppe of *Rhanterium suaveolens* characteristic of the sandy soils of the arid area of Tunisia.

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MATERIALS AND METHODS

Study areas: The experiment was carried out in two sites (Menzel Habib (MH) and Sidi Toui (ST)) located in a region that presented an aridity gradients.

The site of Menzel Habib (34°15'N and 9°39'E) is characterized by an arid Mediterranean bioclimate with a moderate winter. The mean annual rainfall is 175 mm. Soils of the experimental area are sandy and covered by a *Rhanterium suaveolens* steppe. The second site consists of the national park of Sidi Toui (32°43' N and 11°15'E) located at the limits of the arid and the saharian bioclimates. The rainfall is irregular with a mean annual precipitation of about 100 mm. Only the steppe of *Rhanterium suaveolens* on sandy soils is used for the investigation.

The experiment was conducted in spring 2004 both inside the Protected areas (P) of MH (17 years) and the national park of ST (13 years) and in their surrounding areas (G) which are subjected to continuous extensive grazing.

Measurements and data analysis: The following observations and measures were carried out:

- In each area (P or G) of both study sites, five 20 m long transects were set up in order to measure total plant cover and individual species cover using the quadrat point method (Daget and Poissonet, 1971). A line transect was established in each area. Observations were done every 20 cm, for a total of 500 points along the transect to determine cover of the target grass species *S. lagascae* as well as *R. suaveolens*.
- In each area, densities of *S. lagascae* and *R. suaveolens* per m^2 were determined within five 20 m^2 area quadrats.
- All data were subjected to analysis of variance on the basis of the split-plot statistical model by using SPSS (11.5). Site (MH or ST), management mode (P or G) and species (*S. lagascae* or *R. suaveolens*) were the independent variables while global plant cover, species cover and density were the dependent variables.

RESULTS

Climatic conditions during the year of the investigation: The total quantity of rainfall, recorded at MH during the biologic year 2003/2004, is 150 mm. Precipitation started very early with a good quantity during the month of September (53 mm) and was well distributed in time. On the other hand, the experiment year was very wet in ST, the most arid site (Table 1). The recorded quantity of rainfall was very high nearly double the mean annual precipitation. However, the biologic year 2003/2004 was characterized by a very dry fall with the low quantities recorded in September and November (13 and 4 mm respectively). According to Floret and Pontanier (Floret and Pontanier, 1982), only rains higher than 10 mm are efficient and beneficial for vegetation in arid areas.

Table 1: Monthly rainfall (in mm) recorded at the sites of Menzel Habib and Sidi Toui during the experiment year (2003/2004)

	S	O	N	D	J	F	M	A	M	J	J	A	Total
Menzel Habib	51	14	21	44	4	0	16	0	0	0	0	0	150
Sidi Toui	13	0	4	88	54	52	37	0	0	0	0	0	248

Table 2: Variation of total plant cover (%) and *S. lagascae* and *R. suaveolens* covers (%) and densities (Plantsm^{-2}) both in the Protected (P) and in the Grazed (G) areas of Menzel Habib and Sidi Toui

	Menzel Habib		Sidi Toui	
	P	G	P	G
Total plant cover (%)	77.5±11.37	39±5.56	49.66±8.27	19.2±6.33
S. lagascae cover (%)	17±4.6	1±0.57	21.4±4.69	2.6±1.17
R. suaveolens cover (%)	15±5.37	5±2.2	8.64±3.41	5.28±2.29
S. lagascae density	1.83±0.5	0.13±0.06	21.4±10.69	2.6±1.17
R. suaveolens density	0.34±0.1	0.13±0.05	8.64±3.41	5.28±2.29

Total plant cover: The analysis of variance ($R^2 = 0.91$) of total plant cover produced highly significant differences (0.001) between the two sites as well as between the two applied management modes but the interaction between these factors was insignificant.

Total plant cover was higher in P for both sites but lower at ST. The effect of protection on plant cover decreases with aridity (Table 2).

Cover of *Stipa lagascae* and *Rhanterium suaveolens*: The statistical analysis of the plant cover (Adjusted $R^2 = 0.650$) of both species produced significant differences for management mode (.001), species (.04) and the interaction of these two variables (.01) but the effect of site was not significant.

Regardless of site, the highest mean covers of both species were recorded at the protected areas (Table 2). However, the contribution to plant cover of both species varied according the management mode. In the degraded areas, *R. suaveolens*, had relatively higher cover than *S. lagascae* (5 versus 1% at Menzel Habib and 5.28 versus 2.6% at Sidi Toui, respectively). On the contrary, *S. lagascae* the perennial grass was more abundant in the protected areas than grazed areas (17 versus 15% at Menzel Habib and 21.4 versus 8.64% at Sidi Toui, respectively).

Plant density: Plant density was significantly (.001) affected by management, by species and interaction. However this parameter seems to be independent of the site location as there was no difference between sites.

For both species, density was measurably higher in the protected areas than in areas open to grazing (Table 2). If species are considered, the gap between *S. lagascae* and *R. suaveolens* densities was more obvious in the protected areas. The density of the grass species varied from 1.7 at Menzel Habib to 1.83 individuals per m^{-2} at Sidi Toui while that of the chamaephyte was 0.34 individuals per m^{-2} in both sites. In the degraded grazed areas, both species densities were similar (about 0.13 individuals per m^{-2}).

DISCUSSION

The results suggest that the site location (the aridity gradient) affected significantly only the total plant cover. Despite the high amount of precipitation recorded at the aridest site (Sidi Toui) during the experimental year, the precocity as well as the good distribution of rains at Menzel Habib, had a beneficial effect on the development and on the growth of perennial and annual species. In arid areas, annual species richness is indeed a difficult parameter to interpret. A favourable rainfall (quantity and uniform distribution) can hide the effect of heavy ecosystem disturbance as well as that of protection (Le Floc'h *et al*., 1999).

The impact of protection on the total plant cover was very clear in both studied sites. These results corroborate those achieved in other ecologically comparable zones (Floret and Pontanier, 1982; Ayyad and El-Kadi, 1982) which indicate progressive increase of the global vegetation cover in the protected areas as compared to the overgrazed areas, characterized by the bare soil extension. In fact, protection permits soil fixation and the improvement of its structure as due to the abundance of litter resulting from trapping plant dead parts (Ould Sidi Mohamed *et al*., 2002).

Comparing plant cover and density of *S. lagascae* and *R. suaveolens*, results showed that both species are considered as protection increasers and grazing decreasers (Noy-Meir *et al*., 1989) since they are largely more abundant in the protected areas. These results are therefore consistent with the results of Floret (1981) who found that restoration was achieved by a constant increase in the density and cover of existing species. They also corroborate the results achieved by Chaieb (1989), in a *Rhanterium suaveolens* steppe in presaharan Tunisia, who studied the density of some species (among them *Stipa lagascae* and *Rhanterium suaveolens*) in relation to species frequency. He recorded a total disappearance of *Stipa lagasace* in the degraded steppes, but a good development of *S. lagasacae* in good condition steppe even though density was lower than 10 individuals m^{-2}.

Cover and density of *R. suaveolens* were higher than those of *S. lagascae* in the overgrazed areas. According to Jauffret and Lavorel (2003), chamaephytes can resist intense or frequent disturbances by growing less tall and resprouting and tend to be less palatable than most grasses. This response is negative because it reflects the concurrent degradation of vegetation cover and soil (Van de Koppel and Rietkerk, 2000). The low values recorded for *S. lagascae* confirms the weak resistance of grasses to continuous grazing. This species is threatened outside the protected areas where only some scattered individuals remained within the protection of the tufts of some woody species. Hendrickson and Berdahl (Hendrickson and Berdahl, 2002) found that the effect of the defoliation on the survival of perennial grass seedlings such as *Thinopyrum intermedium* and *Psathyrostachys juncea*, is more important than the effect of a water stress. According to Floret and Pontanier (1982), the overuse of rangelands leads to the rarefaction or even the disappearance of good pastoral value species, mainly grasses which are appreciated in all circumstances. The rarefaction of grasses constitutes, according to several authors (Ould Sidi Mohamed *et al*., 2002; Le Houerou, 1995), a good indicator of the state of determination of the plant cover. Noy-Meir and Walker (1986) reported that when there is a decrease in grasses whose superficial roots encourage soil aeration there is a decrease of water infiltration coupled with ligneous species regression.

However, in the protected areas the grass species, *S. lagascae* shows very important values of cover and density. These results are consistent with those in other arid areas. Floret and Pontanier (1982) showed that after a five year protection in presaharan Tunisia, a progressive dynamics occurred that encouraged palatable species including grass regeneration. In a degraded Libyan arid zone, receiving only 100 to 250 mm (mean annual precipitation), a 5 year protection permitted spectacular regeneration of palatable species, particularly perennial grasses (Le Houerou, 1995).

The presence of *S. lagascae* in both sites confirms the very wide ecological amplitude of the species. Its higher plant cover as well as density as compared to the chamaephytic species (*R. suaveolens*) in the protected areas may be attributed to the competition phenomena. Westoby (1979) and Shmida and Burgess (1988) developed some competition and complementarity

concepts between species of the arid area. Complementarity according to these authors occurs in case of abundant soil water availability. However, the competition takes place in the case of unfavourable water soil conditions. We conclude that the grass species *Stipa* is able to use more soil water, the limiting factor in the arid areas, than *R. suaveolens*, the chamaephytic species.

From this study we cannot conclude that the historically heavily grazed range is more severely degraded than protected range in terms of vegetation cover. We were only able to make that determination in terms of plant density. Comparing cover or biomass on grazed to ungrazed areas is like comparing a harvested field to one not harvested. Many researchers report differences in cover and biomass between grazed and protected areas but few can conclude long term impacts because animals had harvested the current years growth before they could get the measurements. Since grazing removes a portion of the current years cover it is not possible to determine if the reduction was caused by the long term impact of heavy grazing or the short term seasonal removal of cover. Such studies need to be followed up with plant density as in our study or temporary exclusion of grazing to adequately study the long term impacts. If possible temporary cages should be placed on the heavily grazed treatment or grazing should be deferred in the final year of study until samples can be collected. This is very difficult to accomplish in commonly grazed area and could be done in present study.

Although cover could not be used as conclusive evidence that heavily grazed range is more degraded, it is very important to document as the lower the plant cover the more likely the range will become eroded and degraded. Since vegetative cover was lower on the heavily grazed site it would be less protected from erosion and more likely to become permanently degraded.

Density of perennials is a more reliable measure of long term impact because the perennial species can still be identified and individuals counted even after they are grazed. However it is still more difficult after grazing than in protected areas where the entire plant is present for identification. We can conclude that the long term impact of heavy grazing has had a negative impact by reducing *Stipa* density.

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