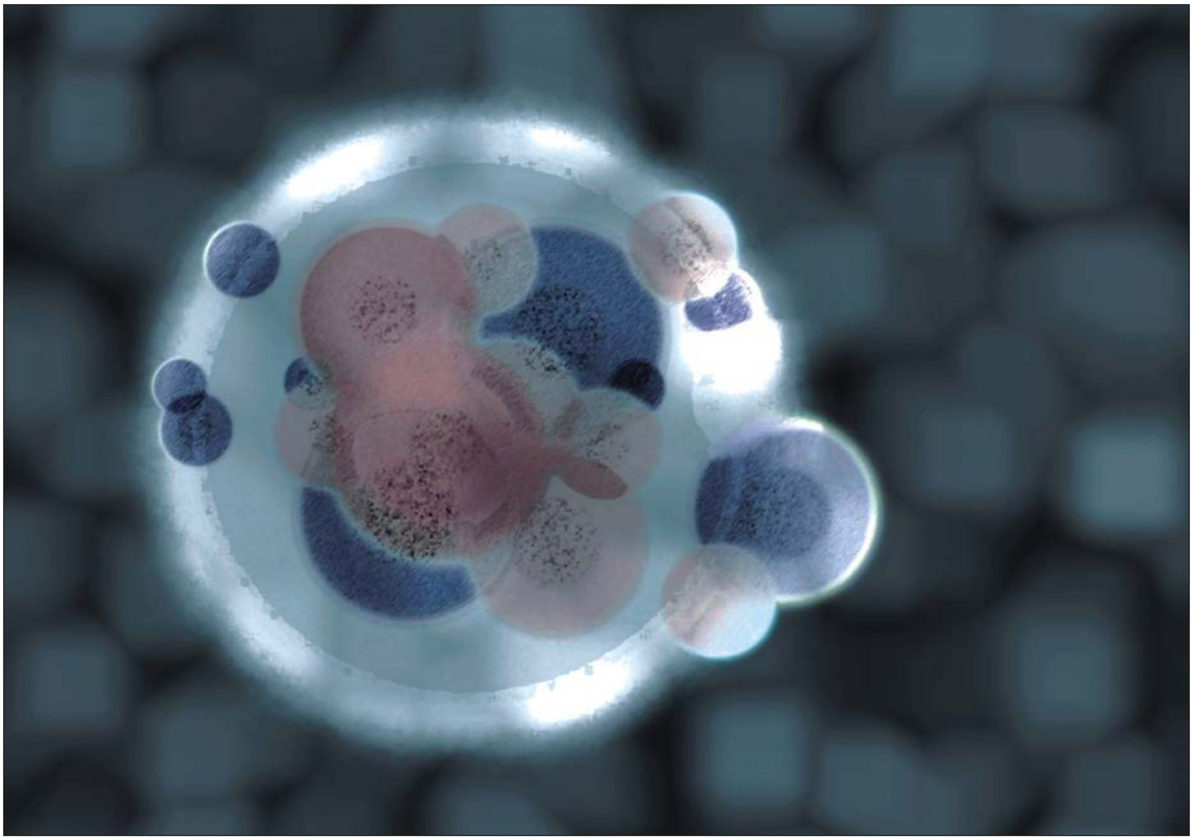

Journal of Biological Sciences

ISSN 1727-3048

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Biological Sciences 7 (8): 1539-1544, 2007
ISSN 1727-3048
© 2007 Asian Network for Scientific Information

Impact of Drought on Plant Cover Dynamics in Two Natural Areas of Southern Tunisia

Farah Ben Salem, Mohamed Tarhouni, Azaiez Ouled Belgacem and Mohamed Neffati
Laboratory of Range Ecology, Institut Des Régions Arides-4119 Médenine, Tunisie

Abstract: The present study deals with the assessment of the effects of drought on the natural plant cover of two natural regions of Southern Tunisia. Several parameters and indicators have been used to describe the evolution of plant communities and their fate under the different constraints and disturbances effect. The main achieved results show that relations between soil and climatic conditions and plant cover are strongly influenced by the human activities impact. The highest specific flora richness has been recorded at the experimental stations of the Jeffara (sandy steppe). The impact of drought on plant cover was more important in the experimental stations presenting higher plant density mainly *Artemisia herba-alba*, *Gymnocarpos decander* and *Hammada scoparia* which are considered as key species of some ecosystems.

Key words: Drought, disturbance, plant communities, dynamics, Southern Tunisia

INTRODUCTION

In Southern Tunisia the desertification has become, since few decades, the principal environmental problem which does not cease worsening. The quarter of the area of this territory was regarded as being very affected by this plague (Tarhouni *et al*., 2007). This zone is more or less marked by the extension of the impact of various human activities (Ouled Belgacem *et al*., 2006). These activities which are mainly expressed by overgrazing and the extension of annual crops at the expense of natural rangelands are more harmful when coupled with the climatic aridity effects. In Southern Tunisia the phenomenon of drought is expressed mainly by an unpredictability of rains and a succession of the dry years. During the last years, a very severe drought happened in Southern Tunisia which has led to the disturbance of the normal functioning of the ecosystems. However, knowledge on this phenomenon, its predictability, its intensity and its effects on plant dynamics remains incomplete (Benzarti and Habaieb, 2001) and studies about the quantification of the impact of the drought all over similar arid areas of the world are rare (Eddy, 2002).

The dynamics of the steppic plant communities seems to permit their constitution between two so long and intense drought periods. Indeed the impacts of the same climatic dryness are more harmful as the ecosystems are subjected to degradation of anthropic origin (Teague *et al*., 2004). Moreover, the drought could result from a total climatic warming and consequently, it is different from the cyclic phenomena that knew the zone. Taking into account the impacts of the drought and degradation of anthropic origin in Southern Tunisia, qualified as without precedent (Jauffret, 2001; Visser, 2002), the identification of the ecological and socio-economic indicators proves to be essential. By definition, an indicator is a parameter, or a computed value starting from a whole of parameters, which provides information on a phenomenon or its state (Patten, 2006). It is conceived for a certain objective and with the profit of a certain user group. Nowadays, the indicators are more and more used in the assessment, monitoring and forecast (Patten, 2006). They also permit to quantify the width and the degree of various biotic and abiotic stresses. According to Tarhouni *et al.* (2006) these indicators are subdivided in two groups: indicators of structure and those of function of the ecological systems. Within the framework of this study, we aim at monitoring some structural indicators such as the total vegetation cover as well as the species richness, life form and density (with the percentage of dead and alive tufts), in order to quantify with some accurate and simple ecological indicators, the response of the plant cover as well as some key species to severe drought. More specifically, we want to know also which are the shares of responsibility for the exploitation by man and drought in the current state of the plant communities in Southern Tunisia.

MATERIALS AND METHODS

Presentation of the sites of study: This study carried out in the two greatest natural areas (Jeffara and the chain of

Corresponding Author: Farah Ben Salem, Laboratory of Range Ecology, Institut Des Régions Arides-4119 Médenine, Tunisie
Tel: 00216 7563 3005 Fax: 00216 7563 3006

Table 1: Mean precipitation recorded in the study stations during different periods

	Mean precipitation (mm $year^{-1}$)				
		From 1999 to 2002 (**)		Sept. 2002 to April 2003 (**)	
Stations	From 1884 to 1977 (*)	Quantity	% (+)	Quantity	% (+)
Jeffara (Stations 1 and 2)	165 (-)	66.33	40.2	143.7	87.09
Matmata (Stations 3 and 4)	123	42.20	34.3	117.1	95.20

*: Floret et Pontanier (1982); **: Data collected from the Agriculture Service of Medenine and Tataouine; +: The percentage is expressed in relation to the mean annual precipitation determined for the period 1884-1997; -: No specific data for these stations between the cities of Medenine and Ben Gardane means of these cities were therefore considered

Matmata) of Southern Tunisia (Fig. 1) which were strongly affected by the effects of drought, having prevails during the period 1999-2002.

Four stations (two in each natural area), located along a gradient of continentality and aridity and considered to be representative of the main plant communities of these zones, were retained within the framework of this study. These communities are characterized as follows:

Station 1 (site of Neffatia, natural area of Jeffara): The plant cover is represented there by a steppe dominated by *Gymnocarpos decander* and *Helianthemum lippii* var. *intricatum* on gypseous soil with accidental relief.

Station 2 (site of El Hemila, natural area of Jeffara): It's a chamaephytic steppe dominated by *Rhanterium suaveolens* on a sandy soil.

Station 3 (site of Gattoufa, natural area of Matmata): The vegetation cover is dominated by a chamephytic steppe with *Artemisia herba-alba* on severe sloppy mountainous area.

Station 4: (site of Douiret, natural area of Matmata): The vegetation is based on a grassland steppe dominated by *Stipa tenacissima* on a calcareous soil.

The analysis of the data of Table 1, shows that the period 1999-2002 was really dry on the level of both studied areas since the mean precipitation recorded during this period was only 40.2 and 34.3% compared to the mean annual precipitations of the Jeffara and Matmata, respectively. Biological year 2002-2003, during which we conducted this study, was relatively more humid than the three years left although recorded precipitations remain lower than the mean annual of two areas.

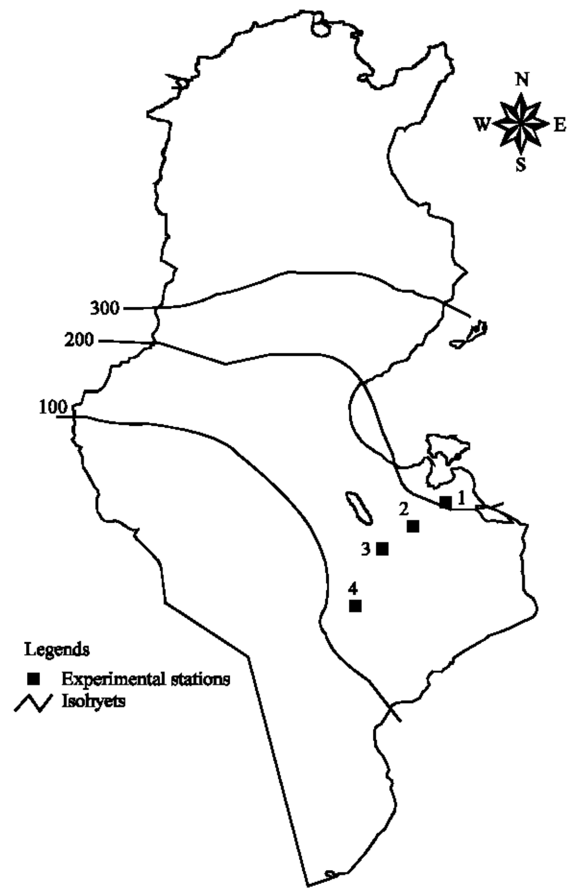

Fig. 1: Geographical location of the experimental stations in Southern Tunisia about the monitoring of plant cover in relation to the impact of drought

Plant cover parameters assessment: The methodology adopted for the characterization of the state of the plant cover is that of the point's quadrants as defined by Daget and Poissonnet (1971). Ten 20 m transects were established in each studied station by the end of spring 2003 (April and May). The main indicators retained for the characterization of the state of the studied phytocoenoses are: (i) the Total Vegetation Cover (TVC), determined by the formula TVC = (n/N)*100, with n: number of points where the vegetation is present and N: number of total sampled points (100 points for our case), like that for annual and perennial plant covers (ii) the species richness and (iii) density of perennial and annual species and that of the old and young plants (desiccated or alive). The plant density is measured in ten 20 m^2 area sampling units.

The data obtained were subjected to several statistical analyses (One-way ANOVA, Tukey LSD test and dependant t-test) with the help of software SPSS 11.5 (SPSS Inc., 2002).

RESULTS

The TVC varies from 30% in the Jeffara to 40.3% at Matmata. The contribution of the perennial species to this cover exceeds 25% in both stations of Jeffara and it is higher than 37% in Matmata (stations 3 and 4). The weak rates of TVC (stations 1 and 2) can be explained by the accentuated overgrazing which results in a reduction of the aerial parts of the plants (Table 2). It seems that the TVC varies significantly according to the natural areas (Jeffara and Matmata) and to the studied stations. Also the perennial species cover in stations 1 and 2 differs significantly from station 4 ($p<0.0001$). The importance of TVC in station 4 can be explained by the vegetative port of the dominant species (*Stipa tenacissima*) known as cumbersome.

In spite of their localization in the same area, stations 3 and 4 have significantly different annual species cover ($p<0.003$). On the other hand the variation of this parameter between stations 1 and 4, characterized by different substrates and topography, is not significant.

The results of the species richness of the studied stations (Table 3) show that steppes with *Gymnocarpos decander* (station 1) and at *Rhanterium suaveolens* (station 2), located in the Jeffara, present the highest values (25 and 22 species, respectively). The species richness of the steppes of *Artemisia herba-alba* (station 3) and of *Stipa tenacissima* (station 4), located in the mounts of Matmata, is relatively weaker (18 and 14 species, respectively). The higher species richness in Jeffara can result in a higher capacity of resistance of these ecosystems to the overgrazing and drought.

Structure of settlements: The analysis of this Table 4 shows that the highest density of the dead young and adult tufts was recorded at the level of both Matmata stations and station 1 of Jeffara. In Jeffara station 2, green tufts either adult or young dominate. All these results show that the ecosystems of the sandy steppe (station 2) are more resilient and consequently expressed a greater capacity of regeneration after this drought while benefiting from the quantity of rain (143.7 mm) which encourage a quick establishment of seedlings and a better adaptation of adult plants.

By considering the two descriptors at the same time (Table 5), total density of the bio-indicator species of the studied phytocoenoses and percentage of the dead tufts of these species and by considering two classes for each one of these two descriptors (weak and raised), four types of plants can be distinguished:

- Plants with low total density and high percentage of dead tufts; they are the plants the most vulnerable to the effects of the drought. *Deverra tortuosa* is the best example of this category of plants and especially in station 1.
- Plants presenting high total density and low percentage of desiccated tufts (9%). In fact the plants prove to be the least vulnerable to the effect of drought such is the case of *Helianthemum kahiricum* in station 1.
- Plants of low density (*Hammada schmittiana* = 705 individuals ha^{-1}) and very low percentage of dead tufts. They are plants which remain lightly or not influenced by the effect of the drought.
- Plants with high densities and high percentage of dead tufts. The main species of this class are *Artemisia herba-alba* (station 3) and *Helianthemum kahiricum* (station 2) (Table 5). Such percentage can be explained by inter-species competition for the available quantities of soil water (Westoby, 1980; Shmida and Burgess, 1988). For a low annual rainfall, the interspecific competition will be exerted to the detriment of all the individuals of which each one will try to benefit from a limited spacio - temporary water reserve (Chaieb, 1993).

Table 2: Variation of total vegetation (TVC) and annual (AC) and perennial (PC) cover (%) in the four studied stations

Cover (%)	Station 1	Station 2	Station 3	Station 4
TVC	26.6±6.57	33.0±3.57	37.6±5.60	43.1±5.36
AC	0.7±0.42	7.1±2.05	4.7±2.43	0.8±0.96
PC	25.8±6.54	25.9±3.27	32.9±3.99	42.3±4.80

Table 3: Comparison of current and original flora richness in the most represented natural areas of Southern Tnnisia (Jeffara: station 2 and Matmata: station 3)

	Steppe of *Rhanterium suaveolens* (station 2)			Steppe of *Artemisia herba-alba* (station 3)		
	Initial state (original vegetation) (a)	Current state (b)	b/a (%)	Initial state (original vegetation) (a)	Current state (b)	b/a (%)
Flora Richness	64	22	34 ≈ 1/3	88	18	20 ≈ 1/5

Table 4: Variation of density of dead and alive tufts, young or adult in the four studied stations

Density (m^2)	DY	GY	DA	GA
Station 1	1.49±0.91	1.84±0.72	1.00±0.26	1.60±0.39
Station 2	0.34±0.09	0.91±0.25	0.80±0.25	1.60±0.28
Station 3	0.65±0.11	0.62±0.13	1.98±0.53	2.18±0.38
Station 4	0.27±0.13	0.30±0.16	1.29±0.29	1.01±0.27

DY: Dried Young plant; GY: Green Young plant; DA: Dried Adult plant; GA: Green Adult

Table 5: Percentage (a) of dead tufts of some bio-indicator species and their total density (b) per ha in the study stations

	Station 1		Station 2		Station 3		Station 4	
Bio-indicator species	a	b	a	b	a	b	a	b
Artemisia herba-alba	-	-	-	-	35	18275	24	2675
Atractylis serratuloides	18	4225	20	1275	0	0	24	300
Gymnocarpos decander	9	8100	21	925	21	1350	14	1250
Hammada schmittiana	7	250	0	705	-	-	-	-
Hammada scoparia	-	-	-	-	12	3725	0	200
Helianthemum kahiricum	9	13825	23	4025	32	3050	19	5750
Deverra tortuosa	52	450	10	125	-	-	-	-
Rhanterium suaveolens	5	50	26	4350	-	-	-	-
Stipa tenacissima	-	-	-	-	0	0	19	4125

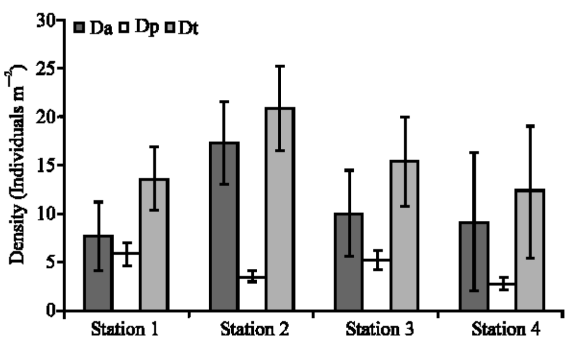

Fig. 2: Variation of total (Dt), annuals (Da) and perennial (Dp) density in the four studied stations in Southern Tunisia

The mean density of the annual and perennial species determined in the four studied stations (Fig. 2) show that this descriptor varies highly according to the stations and to the species life cycle (annuals and perennials).

Figure 2 shows that the density of annuals is higher than that of perennials in all studied stations. Let's recall that, in term of TVC and species richness, the perennial species are the most dominant. Such result shows that the annual species cover less significant area than that of perennial even if their number is higher and are of this fact of smaller size. It is probable that these species quickly benefited from a relatively rainy year which succeeded a long period of drought. Low TVC as well as low species richness of annuals are therefore compensated by very high densities.

DISCUSSION

The results of the study indicate that the Total Vegetation Cover (TVC) varies significantly in relation to plant communities (stations) and that the contribution of perennial species to TVC is more significant than that of annuals. This strong similarity between the cover of perennials and TVC in all studied stations shows that the contribution of annuals to TVC is low or even negligible compared to those of perennials. During spring, annuals play a significant role in the increase of TVC (Enright *et al*., 2005), which is not the case for present study although the year is relatively rainy. This can be explained by the fact that the majority of annuals were of small size and grazed. The levels of perennials cover, which are overall rather low, remain higher than the critical point (20-25%), with the lower part of which, according to Le Houérou (1995), wind erosion appears.

It is to be announced that the negative impact of drought, on the species richness, is felt in the weak resilient ecosystems (Matmata) that in strong dynamics ecosystems (Jeffara). The increase in grazing pressure during the dry periods is responsible for the changes of the composition and the structure of vegetation (Metzger *et al*., 2005; Westbrooke *et al*., 2005). This species richness relatively more raised, remains very low compared to the species composition of the original steppes in good condition such as they were determined by Le Houérou (1969) (88 species for the steppe with *Artemisia bleached on grass-alba* and 64 species for the steppe with *Rhanterium suaveolens*) (Table 3). In the event of climatic variations or anthropic disturbances, the steppes ready to maintain functional structure are those which can have gone up one biological and considerable (sandy steppe) speed of cicatrisation (impact strength) enabling them to ensure the biological balance of plant cover (Jauffret, 2001).

As some desiccated individuals (of the same species) could take again their vegetative activity following the fall rains recorded in October 2002 whereas others perished and this in spite of the apparently homogeneous conditions of the environment. The assumptions that can be advanced to explain such a phenomenon bring back to the seedlings age and the strength of their aerial part. The oldest seedlings and most vigorous seem to be more vulnerable to the effects of the drought (Our obs.). The nature of the edaphic substrate supports or softened the effects of drought on the vegetation. Indeed Pueyo and Alados (2007) noted that a gypseous soil supports the formation of crust and amplifies the effects of the aridity. This also corroborates our results found in station 1.

The difference in density between the perennial species and the annuals can be explained by the great aptitude of the latter to occupy the disturbed sites. One can also think of the importance of their soil seed-bank but also of the low palatability of some among-them. The great reproductive capacity of some species (Neffati, 1984), their aptitudes for the multiplication by vegetative way and their resistance to drought could be at the origin of this high density. This more significant density, of annuals, in the natural area of Jeffara can be explained by the efficiency of the water operation of the sandy soil compared to the calcareous one which dominates in Matmata (stations 3 and 4) (Floret and Pontarier, 1982). The monitoring of the evolution of the plant density gives, however, a more reliable idea on the tendencies to the establishment or the disappearance of the individuals and makes it possible to evaluate the aptitude of the ecosystem to be regenerated (Floret, 1988). The higher the number of individuals is, the stronger and larger capacity of impact (station 2) in particular through characteristics of the species. Moreover, a high number of individuals supports the fixing of the soil particles, which supports in its turn the improvement of the water assessment and thus the re-establishment of species (Floret and Pontanier, 1982; Jauffret, 2001).

Based on these results, it seems that the impact of drought on plant cover dynamics in the Jeffara is less significant then in Matmata.

CONCLUSIONS

Conducted in two natural areas (Jeffara and Matmata) of Southern Tunisia, this study which aims to quantify the effect of the drought on the dynamics of four different plant communities permitted to achieve the following results:

- The studied plant communities knew a considerable impoverishment since their current species richness account for only the 1/3 and the 1/5 in Jeffara and Matmata respectively compared to the species composition of the original vegetation. This impoverishment of the floristic diversity is attributed to the various stress and disturbance types such as drought and overexploitation;
- In both natural areas and for the whole of the studied plant species, the majority of the old and vigorous seedlings seem to be more vulnerable to the effects of the drought than the young individuals;
- The natural plant cover of Jeffara proved to be more resistant to the drought not only because of the nature of its floristic procession, but also the nature of the physical substrate since it is about a sandy soil characterized by its water efficiency;
- The effect of drought is accentuated by the dynamic state of the young individuals as it can be attenuated by the state of the nature of the soil.

REFERENCES

Benzarti, Z. and H. Habaieb, 2001. Study of the persistence of the dryness in Tunisia by the use of the chains of Markov (1909-1996). Sécher., 12: 215-220.

Chaieb, M., 1993. Ecophysiologic response of three perennial graminaceous subjected to contrasted ecological conditions in arid medium in Tunisia (study in natural condition, semi-controlled and controlled). Ph.D Thesis, Sci. Univ. Sfax., pp: 238.

Daget, P. and J. Poissonnet, 1971. A method of phytologic analysis of the meadows. Criteria Applic. Agron. An., 22: 5-41.

Eddy, D.P., 2002. Drought in WANA: Six frequently asked questions. J. Carav. ICARDA., 17: 12-17.

Enright, N.J., B.P. Miller and R. Akhter, 2005. Desert vegetation and vegetation-environment relationships in Kirthar National Park, Sindh, Pakistan. J. Arid Environ., 61: 397-418.

Floret, C. and R. Pontarier, 1982. Aridity in presaharanne Tunisia: Climate, ground, vegetation and installation. Work and document of the ORSTOM. No. 150. Paris, pp: 544.

Floret, Ch., 1988. Methods of Measurement of the Pastorale Vegetation: Pastoralism and Development. CIHEAM, Montpellier, France, pp: 95.

Jauffret, S., 2001. Validation and comparison of various indicators of the long-term changes in the arid Mediterranean ecosystems: Application to the follow-up of the turning into a desert in Southern Tunisian. Ph.D Thesis, Univ. Aix-Marseille.

Le Houérou, H.N., 1969. Vegetation of steppic Tunisia. Ann. INRAT Tu., 42: 624 p. + appendix and map 1/500000 in colors.

Le Houérou, H.N., 1995. Bioclimatology and biogeography of the arid steppes of the North Africa. Biological diversity, durable development and desertisation. CIHEAM Opt. Médit., Sér B- No. 10, pp: 396.

Metzger, K.L., M.B. Coughenour, R.M. Reich and R.B. Boone, 2005. Effects of seasonal grazing on plant species diversity and vegetation structure in a semi-arid ecosystem. J. Arid Environ., 61: 60-147.

Neffati, M., 1984. Allelopathic behavior of *Artemisia campestris* L. in the range lands of Tunisian Djeffara. Memory of End of Studies, INAT Tunis.

Ouled Belgacem, A., M. Chaieb, M. Neffati and J. Tiedeman, 2006. Response of *Stipa lagascae* R. and Sch. to protection under arid condition of Southern Tunisia. Pak. J. Biol. Sci., 9: 465-469.

Patten, B.C., 2006. Network perspectives on ecological indicators and actuators: Enfolding, observability and controllability. Ecol. Indicat., 6: 6-23.

Pueyo, Y. and C. Alados, 2007. Abiotic factors determining vegetation patterns in semi-arid Mediterranean landscape: Different responses on gypsum and non-gypsum substrates. J. Arid Environ., 69: 490-505.

Shmida, A. and T.L. Burgess, 1988. Plant Growth-Form Strategies and Vegetation Types in Arid Environments. In: Plant Form Vegetation Structure. Werger, M.J.A., P.J.M. Van Der Aart and J.T.A. Ver Deven (Eds.), Academic Publishing, The Hague, The Netherlands.

SPSS, 2002. SPSS: SPSS 11.5 for Windows Update, SPSS Inc., USA.

Tarhouni, M., A. Ouled Belgacem, M. Neffati and B. Henchi, 2006. Validation of some ecosystem structural attributes in relation to the effect of seasonal drought and animal pressure around watering points in the arid area of Tunisia. Belg. J. Bot., 139: 188-202.

Tarhouni, M., A. Ouled Belgacem, M. Neffati and B. Henchi, 2007. Qualification of rangeland degradation using plant life history strategies around watering points in Southern Tunisia. Pak. J. Biol. Sci., 10: 1229-1235.

Teague, W.R., S.L. Dowhower and J.A.Waggoner, 2004. Drought and grazing patch dynamics under different grazing management. J. Arid Environ., 58: 97-117.

Visser, M., 2002. Rehabilitation of the degraded grounds in arid region by reintroduction of autochtones species: Installation of an integrated system to product seeds of quality. Report/Ratio of Final Mission, FTT 01.11.1998-31.10.2002.

Westbrooke, M.E., S.K. Florentine and P. Milberg, 2005. Arid land vegetation dynamics after a rare flooding event: Influence of fire and grazing. J. Arid Environ., 61: 294-260.

Westoby, M., 1980. Elements of a theory of vegetation dynamics in arid rangelands. Israel J. Bot., 28: 169-194.